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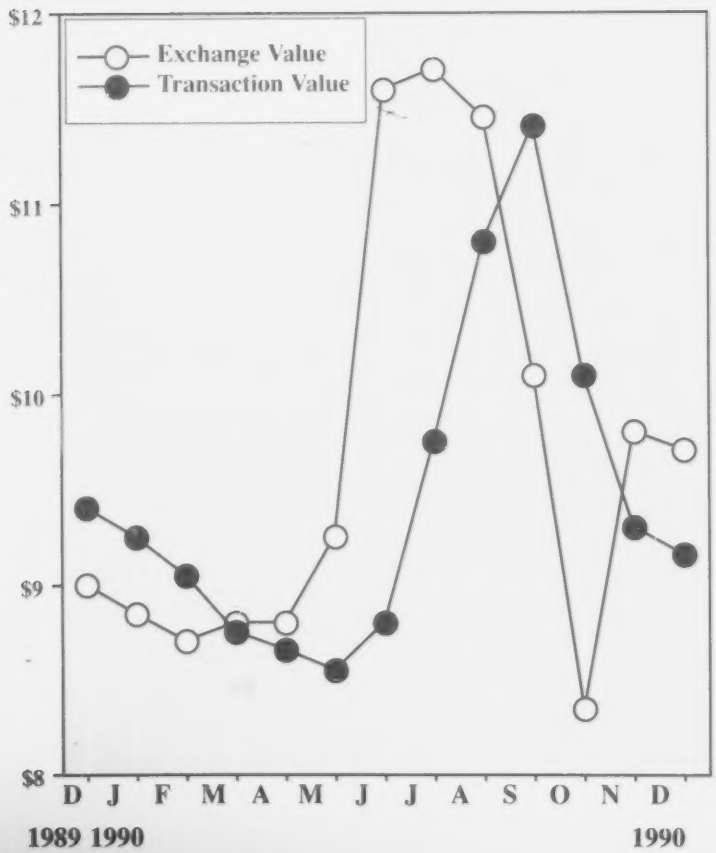
NUEXCO

1990 Annual Review



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NUEXCO

To Our Readers

NUEXCO is pleased to present its *1990 Annual Review*. Each year the *Annual Review* requires the efforts of many NUEXCO professionals, without whose contributions the publication would be impossible. The editors appreciate their efforts and trust our readers will find the *Annual Review* informative and useful.

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MARKET DEVELOPMENTS

NATURAL URANIUM

Overview

After two years of steady price declines, the spot uranium market exhibited unusual volatility during the course of 1990. Prices began the year under $9.00 per pound U_3O_8, as the market was characterized by ample supplies, modest demand, and record low price levels. By May 1990, however, discretionary buyers emerged in force, and cautious sellers began pulling back from the market. During a span of several weeks, the spot price had climbed to $11.70 per pound U_3O_8. Almost as rapidly, discretionary buyers left the market, and the increased number of sellers drawn into the market by relatively high prices soon competed for every opportunity. As a result, the price dropped back below $9.00 per pound in October, rebounding to $9.70 by the end of the year. (**Table 1**)

The volatility was brought on by a number of factors, including increased trading on the spot market and the rapid entry and exit of large blocks of discretionary demand, including that of several producers. Nevertheless, most of the fundamental market forces in effect in 1988 and 1989 still existed as of the end of 1990. The uranium inventory oversupply situation changed little. The drawdown of inventories, and purchasing activity by many producers,

Table 1
1990 NUEXCO NATURAL URANIUM
SPOT MARKET PRICE INDICATORS

Determined as of the Last Day of the Month	Published in Report Number	Exchange Value [1] (Per Pound U_3O_8)	UF_6 Value [1] (Per Kg U as UF_6)	Transaction Value [1] Per Pound U_3O_8	Number of Transactions	Number of Months	Million Pounds Equivalent U_3O_8
January	258	$ 8.85	$25.90	$ 9.25	17	3	4.0
February	259	$ 8.70	$25.25	$ 9.05	22	3	5.8
March	260	$ 8.80	$24.40	$ 8.75	13	3	4.4
April	261	$ 8.80	$24.40	$ 8.65	24	3	8.4
May	262	$ 9.25	$25.50	$ 8.55	27	3	9.9
June	263	$11.60	$32.00	$ 8.80	38	3	11.3
July	264	$11.70	$32.50	$ 9.75	35	3	9.1
August	265	$11.45	$32.25	$10.80	27	3	5.5
September	266	$10.10	$29.50	$11.40	15	3	3.7
October	267	$ 8.35	$24.75	$10.10	12	3	2.3
November	268	$ 9.80	$28.75	$ 9.30	16	3	3.0
December	269	$ 9.70	$28.75	$ 9.15	19	3	3.1
Averages [2]		**$9.76**	**$27.83**	**$ 9.28** [3]	**22**	**3**	**5.9**

[1] Refer to the **Market Values Definition** in the **Index Section** for further descriptions.

[2] Simple arithmetic averages, except where noted.

[3] Volume-weighted annual average.

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actions that could eventually lead to recovery, were offset in 1990 by the emergence of new suppliers, particularly the Soviet Union and eastern Europe. Sellers that once avoided selling on the spot market in hopes of future price increases began participating, due to cash flow concerns or the growing sentiment that a substantial recovery was unlikely in the next few years. Utility concerns over a significant price rise or the need to carry large inventories gradually subsided; many US utilities are now pursuing zero-inventory policies. Despite the price volatility, market expectations continue to be focused on low uranium prices.

Uranium spot-market volume reached a new record level in 1990: over 40 million pounds U_3O_8 equivalent changed hands in 118 transactions reported by NUEXCO (**Figure 1**). The previous record was set in 1989, when spot volume reached 32.3 million pounds U_3O_8 equivalent in 107 transactions. Other records set in 1990 include the largest percentage increase in the NUEXCO Exchange Value—a 25-percent rise from $9.25 to $11.60 during the month of June. In addition, the $8.35 reported on October 31, when adjusted for inflation, represents the lowest historical Exchange Value (**Table 2**).

The reasons behind the increased volume and volatility, as well as fundamentally low prices, are as follows:

- The emergence of China, the Soviet Union, and various eastern European countries as suppliers or potential suppliers of uranium, contributed to a strong market perception of excess uranium available to the market. Other contributing factors included Namibian independence, which led to the removal of US sanctions against Namibian material in March 1990; the aftereffects of the US-Canada Free Trade Agreement, which effectively silenced proponents of US mining protectionism; and the entrance into the market of a few large inventories of natural and enriched uranium, such as the German government's stockpile material and the Queensland Mines inventory. Furthermore, most traditional producers in the USA, Canada, and Australia were either reluctant or unwilling to shut down high-cost facilities or forego market share until well into 1990.
- The general market perception of plentiful supplies led to different reactions on the part of buyers and sellers. Many utilities deferred or eliminated plans to purchase on a discretionary basis. For sellers, chiefly traders and some producers, optimism over rising prices evaporated during 1990, and many believed that selling at a low price was preferable to selling at an even lower price later in the year.
- The growing role of traders in the spot market led to greater spot market volume and increased market activity. While contributing to greater competition among sellers, the increased activity also resulted in more frequent price swings, as a greater number of suppliers quickly moved in and out of the market.

Figure 1
SPOT AND NEAR-TERM URANIUM SALES VOLUME – 1984-1990

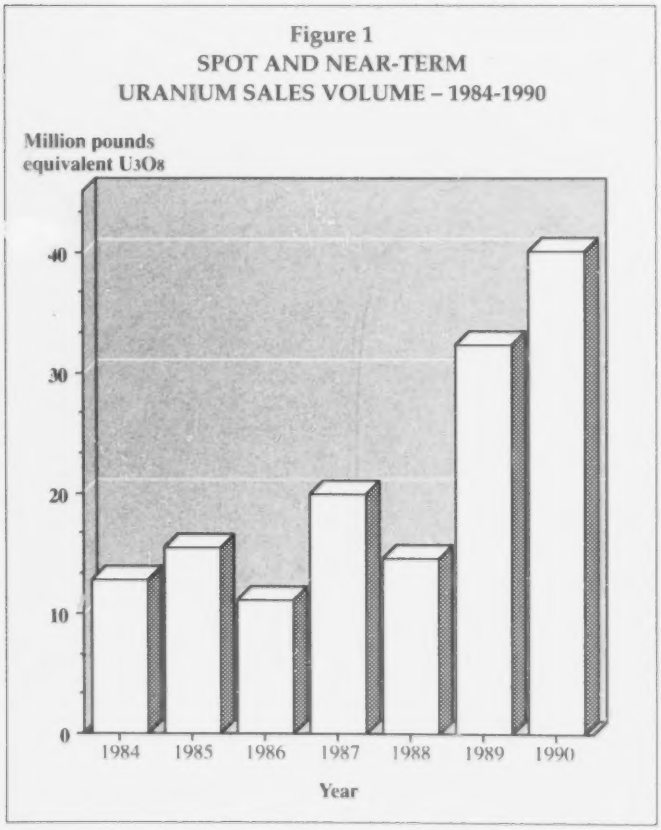

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Table 2
1990 NUEXCO EXCHANGE VALUE
EXPRESSED IN SELECTED CURRENCIES[1]

Country (currency)	(Per pound U_3O_8 as Concentrates) December 31, 1989	March 31, 1990	June 30, 1990	September 30, 1990	December 31, 1990	December 31, 1990 Related to December 31, 1989
Australia (dollar)	11.33	11.70	14.74	12.22	12.58	+11.0%
Belgium (franc)	319.60	309.10	398.63	324.55	299.57	- 6.3%
Canada (dollar)	10.41	10.31	13.56	11.67	11.25	+ 8.1%
EC (ecu)	7.48	7.32	9.38	7.69	7.17	- 4.1%
Finland (markka)	36.30	35.29	45.58	37.37	35.13	- 3.2%
France (franc)	52.08	50.25	65.14	52.73	49.32	- 5.3%
Germany (mark)	15.23	14.93	19.39	15.77	14.50	- 4.8%
Italy (lira)	11,390	11,011	14,233	11,796	10,922	- 4.1%
Japan (yen)	1,296	1,377	1,775	1,393	1,309	+ 1.0%
The Netherlands (guilder)	17.17	16.82	21.83	17.77	16.35	- 4.8%
South Africa (comm. rand)	22.83	23.33	30.79	25.96	24.88	+ 9.0%
South Korea (won)	6,097	6,086	8,201	7,222	6,931	+13.7%
Spain (peseta)	985.11	956.11	1,191	986.81	927.79	- 5.8%
Sweden (krona)	55.83	53.95	70.22	58.01	54.56	- 2.3%
Switzerland (franc)	13.90	13.17	16.48	13.06	12.38	-10.9%
Taiwan (dollar)	233.64	232.32	313.44	270.68	258.36	+10.6%
UK (pound)	5.62	5.38	6.67	5.37	5.04	-10.3%
US (dollar)	9.00	8.80	11.60	10.10	9.70	+ 7.7%

[1] Calculated using currency exchange rates published in *The Wall Street Journal* on the last working day of the month indicated.

In the first half of 1990, the combination of price-sensitive discretionary buyers and motivated sellers holding large inventories resulted in a protracted period of low prices. Prices rose sharply in May through July due to increased demand and sellers' gradual departure from the market. Once prices exceeded $11 per pound, enough sellers re-entered the market to not only halt the price rise, but to cause another steep drop in prices, down to the level of $8.35 per pound U_3O_8. Essentially the same cycle, though smaller in magnitude, recurred near the end of the year and into 1991.

Overreaction by both buyers and sellers contributed to the price swings in mid-1990. Price swings have been less extreme in the first part of 1991, as buyers and sellers recognize the primary oversupply situation and, consequently, react more calmly to market fluctuations.

Spot Market

The uranium spot market in 1990 was the most active ever: 118 transactions involving 40.1 million pounds equivalent U_3O_8 were recorded (**Table 3**). Natural uranium concentrates made up over half the year's volume, as 23.4 million pounds changed hands in 67 transactions. UF_6 sales accounted for about a quarter of the year's volume, or 9.7 million pounds equivalent U_3O_8 in 37 sales. Enriched uranium product (EUP) sales made up the balance of seven million pounds equivalent U_3O_8. (**Table 4** shows a six-year history of the percentage of spot and near-term deliveries by form of material sold.)

This year's record volume continues the trend toward even greater participation in the spot market. Increased utility reliance on the spot market, active producer buying to fill

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MARKET DEVELOPMENTS

Table 3
SPOT AND NEAR-TERM MARKET VOLUME – 1990

Uranium Form	No. of Sales	Volume[1]
Concentrates	67	23.4
Natural UF_6	37	9.7
EUP	14	7.0
Total	**118**	**40.1**

[1] Million pounds equivalent U_3O_8

contracts, and increased activity by traders all contributed to 1990's record results. The market was most active during the second quarter of the year. Over 21 million pounds were sold in that three-month period. A month-by-month breakdown of near-term uranium sales volume is shown in **Table 5**. The second quarter is traditionally the most active buying period, and low market prices enticed discretionary buyers to make purchases. When prices started to rise even slightly, buyers who feared further increases rushed to conclude purchases and, consequently, sales volume jumped significantly.

Uranium Supply and Demand

Reported active uranium supply averaged almost 4.6 million pounds equivalent U_3O_8 during 1990 (**Table 6**). This is a decrease from 1989's monthly average supply of 5.4 million pounds. For the first time, during the months of March, April, and May, active uranium demand exceeded the supply of material available for sale. However, this development had little tangible effect on the market, due to the vast supply of material available for loan (monthly average of over 7.8 million pounds equivalent U_3O_8).

The natural uranium market is still characterized by a large oversupply of material. Producer, utility, and most significantly, government stockpiles continue to affect the market. In particular, inventory from sources such as the Soviet Union, Germany, and Czechoslovakia, all entered the market or were recognized by the market during 1990.

Active uranium demand averaged 2.5 million pounds equivalent U_3O_8 during the year, but consistently exceeded 4.5 million pounds during March and April (**Table 6**). Active demand actually out-paced active supply during that time, though sufficient supply eventually emerged to meet demand when necessary. The ratio of the year's average supply to demand equalled 1.9 .

Although only a moderate amount of firm demand existed, low market prices enticed many discretionary buyers into the market. As prices settled in the mid-eight-dollar range early in the year, numerous buyers emerged, including several producers, seeking to purchase uranium at record-low levels. Once prices started to rise, the gradual increase in demand turned into a large surge, as buyers hurried to conclude purchases.

Additionally, just as demand increased, several sellers left the market temporarily, leading to the record rise in prices. Consequently, active uranium demand dropped well below one million pounds during the third quarter of the year due to the withdrawal from the market of most discretionary buyers.

Utilities made up the largest buying group during 1990, followed by intermediaries, then producers. The low market prices induced many producers to adopt a non-traditional role as buyers, because concentrates could be purchased cheaper than many producers' cost of production.

Table 4
FORM OF MATERIAL SOLD FOR SPOT AND NEAR-TERM DELIVERY
Percent Share of Volume (1985-1990)

	1985	1986	1987	1988	1989	1990
Concentrates	67.1	42.2	57.0	62.3	74.8	**58.3**
Natural UF_6	31.6	51.0	35.5	27.4	15.9	**24.2**
EUP	1.3	6.8	7.5	10.3	9.3	**17.5**
Total	100.0	100.0	100.0	100.0	100.0	**100.0**

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Transaction Value

The NUEXCO Transaction Value is a moving weighted average of prices paid for natural uranium in recent spot and near-term market sales (**Market Values Definitions** in Index Section). During 1990, the volatility of the uranium market was represented by the wide fluctuations of both the Exchange Value and the Transaction Value. The January 31 Transaction Value was $9.25 per pound U_3O_8; by year-end, it had slipped only to $9.15 per pound. But during the year, the Transaction Value reached as high as $11.40 on September 30, and as low as $8.55 on May 31.

The 1990 weighted average Transaction Value is $9.28 per pound U_3O_8, based on 85 transactions over twelve months involving 22.5 million pounds. Note that an annual weighted average differs from a simple average of the twelve monthly Transaction Values. The annual weighted average counts each transaction only once; it also excludes any 1989 transactions included in Transaction Value calculations for early 1990. The sum of the quantities sold in these 1990 transactions is divided into the product of the price-times-quantity calculations, to yield the weighted-average 1990 Transaction Value.

TRANSACTION ANALYSIS

Spot and Near-Term Sales

Over 40 million pounds equivalent U_3O_8 in the form of concentrates, UF_6, and enriched uranium product (EUP) changed hands in 1990. This volume represents a 24-percent increase over 1989's previous record of 32.3 million pounds. There was also a 10-percent increase in the number of sales (118 versus 107). These figures include all 1990 near-term uranium transactions reported in Monthly Reports #258-269, and nine transactions that occurred in 1990 but were not previously reported. NUEXCO's reporting of nuclear fuel transactions is subject to some limitations. Transactions that may not have been reported include the following:

- Transactions (or certain information about published transactions) which, if reported, would jeopardize client confidentiality.
- Transactions for which insufficient reliable information is available.
- New deliveries, or the exercise of options for additional material, under old contracts are not considered to be new contracts.
- Transactions involving material other than concentrates, natural UF_6, or enriched uranium product .
- Transactions involving back-to-back sales (Generally only one transaction is reported in this case; however, when trading activities are involved, two separate transactions may be reported if warranted.)
- Transactions involving only exchanges of origin, location, form, or other commercially important attributes.

Natural uranium concentrates constituted about 58 percent of the uranium sold in 1990 (**Table 4**). Natural UF_6 accounted for almost one-quarter of the volume. Sales of EUP made up more than 17 percent of the total, the highest percentage ever recorded for EUP volume. **Table 7** shows this data by buyer and seller type.

Table 5
MONTHLY NEAR-TERM URANIUM SALES VOLUME – 1990

Month	Number of Sales	Volume (million pounds equivalent U_3O_8)	Exchange Value (as of the end of the month indicated)
January	2	0.9	$ 8.85
February	14	5.2	$ 8.70
March	8	5.2	$ 8.80
April	14	4.9	$ 8.80
May	13	5.1	$ 9.25
June	26	11.4	$11.60
July	9	2.6	$11.70
August	3	0.4	$11.45
September	4	0.8	$10.10
October	7	0.9	$ 8.35
November	9	2.0	$ 9.80
December	9	0.7	$ 9.70
Total	**118**	**40.1**	

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Table 6
1990 ACTIVE URANIUM SUPPLY AND DEMAND

Determined as of the Last Day of the Month	Published in Report Number	Supply (thousand pounds equivalent U_3O_8)	Demand (thousand pounds equivalent U_3O_8)	Supply/ Demand Ratio
January	258	6,200	2,502	2.5
February	259	5,140	3,720	1.4
March	260	3,840	4,470	0.9
April	261	1,300	4,610	0.3
May	262	3,475	3,670	0.9
June	263	5,175	3,470	1.5
July	264	5,595	405	13.8
August	265	5,400	830	6.5
September	266	5,260	750	7.0
October	267	4,375	1,420	3.1
November	268	4,745	1,795	2.6
December	269	4,400	1,895	2.3
Annual Averages [1]		**4,575**	**2,461**	

[1] Simple arithmetic averages.

Buyers

In 1989, intermediaries had surpassed utilities as the largest buying group by volume; however, utilities regained their position as the primary buyers during 1990. Utilities purchased 40 percent of the material sold, while intermediaries' purchases accounted for 29 percent of the year's volume (**Figure 2**). Significantly, producers emerged in 1990 as a major buying group, accounting for 23 percent of the purchases. In terms of number of purchases, utilities made 50 of the year's 118 purchases, while producers made 38 purchases. Intermediaries made nineteen purchases, though at a higher average volume per purchase than any other group. Other market participants made eleven purchases totalling nearly eight percent of total volume.

US entities purchased 18.5 million pounds equivalent U_3O_8 or 46 percent of 1990's volume. European buyers accounted for 36 percent of the volume, purchasing 14.5 million pounds. Canadian entities, all producers, were next, purchasing eleven percent of the total volume. **Figure 3** shows buyers by origin.

Sellers

Intermediaries dominated this year's market as the primary sellers, accounting for 84 of the 118 sales and 56 percent of the volume (22.6 million pounds equivalent U_3O_8). This 56 percent share is an increase from 1989's level of 46 percent, but lower than the record share of 61 percent that intermediaries earned in 1988. Producers sold 11.6 million pounds equivalent U_3O_8 in 19 sales on the spot market in 1990 (**Table 7**), a 29 percent share of the year's volume. Other entities, which include convertors, fabricators, government entities, and unknowns, sold 3.2 million pounds—eight percent of the year's volume.

US entities were the major sellers in 1990, selling 24.4 million pounds equivalent U_3O_8 in 85 sales. This 61 percent share of total sales volume is just slightly off 1989's level of 63 percent. European and Australian entities each sold 6.8 million pounds equivalent U_3O_8 in 1990. European parties acted as sellers in 21 transactions, whereas an Australian producer sold nearly all of its inventory to a European intermediary.

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Table 7
ANALYSIS OF 1990 SPOT AND NEAR-TERM URANIUM SALES

SALES BY	Concentrates		UF_6		Enriched Uranium Product		Total	
	Number of Sales	Million Lbs. Equivalent U_3O_8	Number of Sales	Million Lbs. Equivalent U_3O_8	Number of Sales	Million Lbs. Equivalent U_3O_8	Number of Sales	Million Lbs. Equivalent U_3O_8
PRODUCERS to:								
Utilities	4	0.8	2	0.9	–	—	6	1.7
Producers	5	1.8	–	—	–	—	5	1.8
Intermediaries	5	7.5	–	—	–	—	5	7.5
Others	3	0.6	–	—	–	—	3	0.6
Total	**17**	**10.7**	**2**	**0.9**	**–**	**—**	**19**	**11.6**
UTILITIES to:								
Utilities	–	—	–	—	–	—	–	—
Producers	1	0.1	–	—	–	—	1	0.1
Intermediaries	–	—	–	—	1	1.0	1	1.0
Others	–	—	–	—	1	1.6	1	1.6
Total	**1**	**0.1**	**–**	**—**	**2**	**2.6**	**3**	**2.7**
INTERMEDIARIES to:								
Utilities	16	4.3	17	5.4	6	2.5	39	12.2
Producers	24	4.7	6	2.2	–	—	30	6.9
Intermediaries	5	1.7	4	0.6	1	0.4	10	2.7
Others	1	0.5	1	0.2	3	0.1	5	0.8
Total	**46**	**11.2**	**28**	**8.4**	**10**	**3.0**	**84**	**22.6**
OTHER ENTITIES to:								
Utilities	1	0.5	2	0.2	2	1.4	5	2.1
Producers	1	0.5	1	0.1	–	—	2	0.6
Intermediaries	1	0.4	2	≤0.1	–	—	3	0.4
Others	–	—	2	0.1	–	—	2	0.1
Total	**3**	**0.4**	**7**	**0.4**	**2**	**1.4**	**12**	**3.2**
TOTAL	**67**	**23.4**	**37**	**9.7**	**14**	**7.0**	**118**	**40.1**

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Long-Term Market

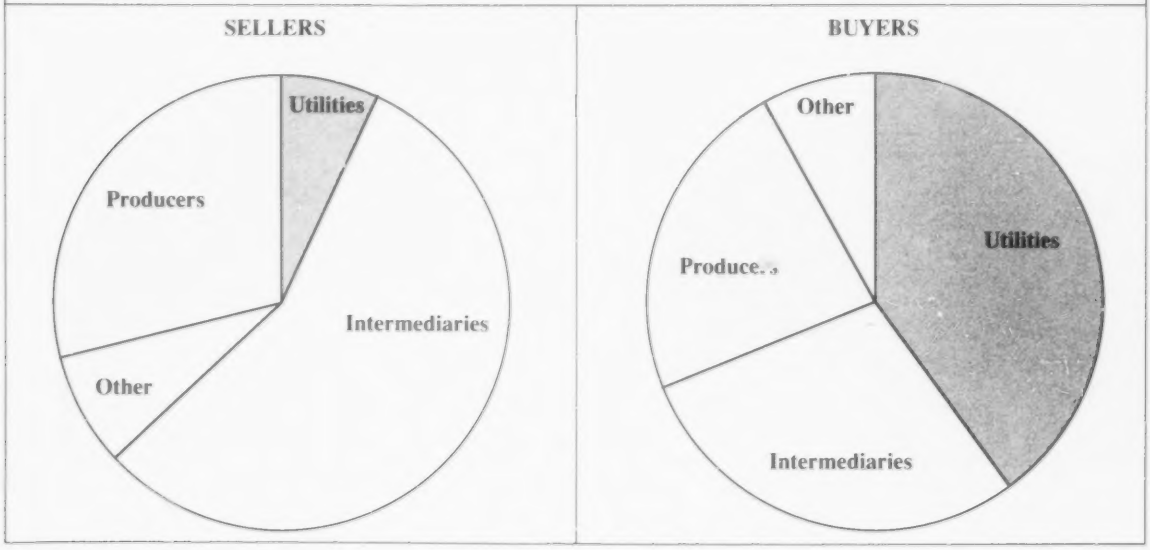
Thirty-seven long-term uranium transactions are reported for 1990 totalling over 54 million pounds equivalent U_3O_8. This is an increase of 60 percent over 1989's level of 23 sales for approximately 34 million pounds. Of these sales, 29 involved concentrates for over 41 million pounds, seven involved UF_6 for almost five million pounds, and one enriched uranium sale involved nearly eight million pounds equivalent U_3O_8. Deliveries of the sales began in 1991 and extend through the year 2001.

The high level of activity in the spot market affected the long-term uranium market. With the record-low spot market prices during 1990, market-related long-term contracts became attractive to many buyers. At least 19 of the contracts signed during 1990 contained market-related pricing mechanisms. Nine contracts utilized base-escalated pricing terms and six contracts had a series of fixed prices for each delivery. The pricing terms of three contracts are unknown.

Utilities purchased over 51 million pounds in 35 of the year's long-term transactions. US utilities predominated, making 24 purchases for almost 30 million pounds. European utilities purchased over 13 million pounds in nine transactions. Asian utilities made the other two utility purchases for over eight million pounds equivalent U_3O_8.

Producers sold over 42 million pounds equivalent U_3O_8 in 27 of the long-term sales. Intermediaries made the other ten sales for over 12 million pounds. Canadian producers sold the most material, concluding eleven contracts for over 16 million pounds. US producers sold over nine million pounds in eight sales, while Australian producers accounted for almost five million pounds in four sales. Producers from eastern Europe and from Asia made up the balance. Of the intermediary sellers, six were US entities and four were European.

Figure 2
1990 SELLERS AND BUYERS
SPOT AND NEAR-TERM URANIUM TRANSACTIONS
(Percent Share by Volume)



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LOANS

The Loan Rate for natural uranium remained at 3.5 percent per annum throughout the year, unchanged since November 1987. Loan supply was abundant during the year, often exceeding nine million pounds equivalent U_3O_8. Material available for loan added to the market's oversupply situation, as buyers could borrow uranium to fill near-term needs and lenders could earn a positive return on their excess inventory.

Natural uranium loan volume increased substantially in 1990: 30 loans involving over 16 million pounds equivalent U_3O_8 were reported. This compares to 1989's level of 20 loans for 8.8 million pounds. Concentrates were involved in 22 of the loans for nearly ten million pounds, while the other eight loans involved over 6 million pounds equivalent U_3O_8 in the form of UF_6.

Just as last year, utilities were the primary lenders, lending over nine million pounds equivalent U_3O_8 during 1990. However, many other entities began lending material in 1990: producers, intermediaries, and fabricators together lent over 7 million pounds equivalent U_3O_8.

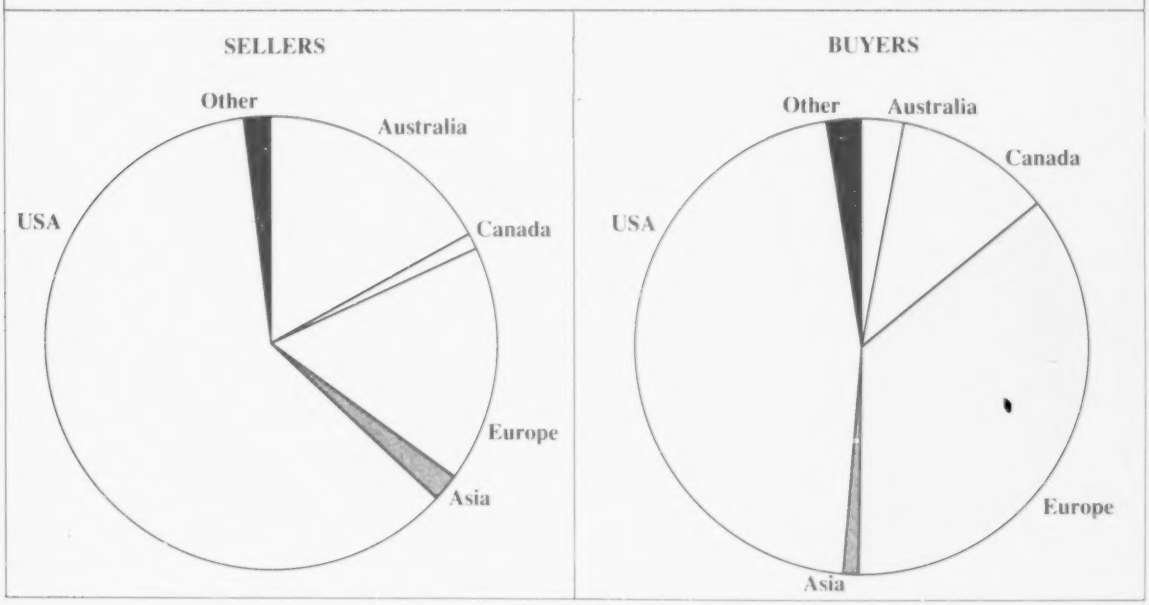
Borrowers were primarily intermediaries, accounting for 23 loans involving over 12 million pounds equivalent U_3O_8. The balance of the borrowing was split almost equally between utilities and producers.

At least ten enriched uranium product loans occurred during 1990. All involved utilities as lenders, with intermediaries and utilities as borrowers. While loans of EUP typically commanded loan fees above the natural uranium loan rate, the rates were still very attractive compared to most utilities' cost of money, and also offered shorter lead-time flexibility unavailable from primary enrichment suppliers.

CONVERSION SERVICES

Prices for conversion services, as indicated by the NUEXCO Conversion Value, remained virtually constant during 1990. The Conversion Value equalled $1.50 per pound U as UF_6 on January 31, 1990, and fell to $1.45 per pound U on March 31. It remained at that level for the rest of the year. NUEXCO's Conversion Value applies to the secondary market, but aggressive competition

Figure 3
SPOT AND NEAR-TERM TRANSACTIONS
1990 PERCENT SHARE BY VOLUME AND ORIGIN OF SELLERS AND BUYERS



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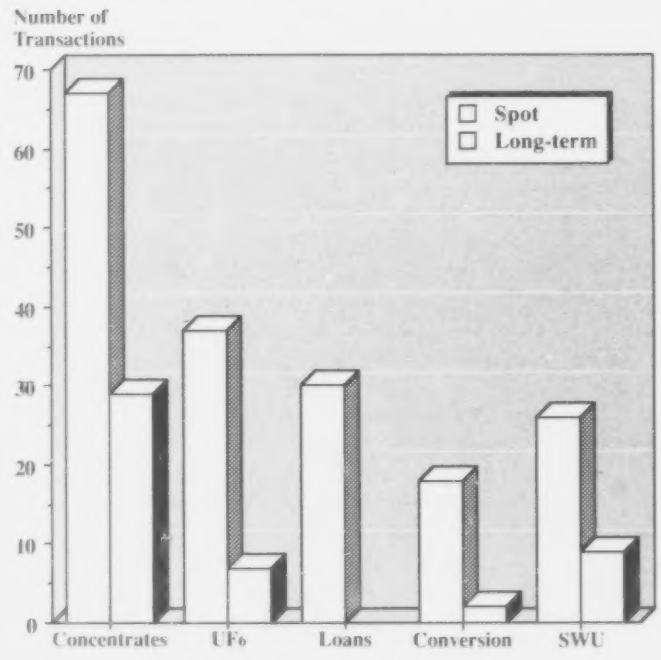
for the very limited demand narrowed the price margin between the primary and secondary conversion markets. In early 1990 in particular, the glut of UF_6 put added pressure on the market, as UF_6 was selling at a substantial discount ($1-2 per KgU) from the sum of the values of its components.

NUEXCO reports 20 conversion transactions in 1990 for almost seven million pounds U. In 1989, that level was 15 sales (1[illegible] near-term and 3 long-term) for 8.1 million pounds U. Of 1990's twenty sales, 18 were for near term delivery, and two (totalling almost one million pounds U) called for intermediate-term deliveries through 1992. Utilities purchased the conversion in all but one of the transactions; a producer purchased less than a half million pounds U in the other. Primary convertors and intermediaries were the main sellers. Intermediaries made 12 sales, and convertors, 6 sales; the other sellers were unknown. US and European buyers split the volume almost equally, though US entities were involved in 12 purchases versus 8 purchases by European buyers.

Figure 4
1990 TRANSACTIONS BY FORM AND TERM



ENRICHMENT SERVICES

Spot Market

The SWU Value began the year at $54 per SWU and dropped to $50 per SWU on February 28. In essence, the drop was the continuation of a slide in SWU prices that began in late 1989. In the face of several large inventory liquidations, the SWU Value dropped from $66 per SWU on July 31, 1989, to $50 by February 28, 1990. Since then, secondary enrichment market price levels have been fairly constant, despite large month-to-month variations in volume. The SWU Value remained at $50 until October 31, when it edged upward to $51 per SWU.

Market activity varied significantly each month. No more than one enrichment transaction was reported during each of the months of April, August, October, and December. June and November had numerous sales, including a few long-term sales, in which several million SWU changed hands. A total of 1.7 million SWU was purchased in 26 near-term SWU and EUP transactions. SWU-only sales (those sales in which the uranium feed component was not sold) totalled 700 thousand SWU in 13 near-term sales. With only two exceptions, every near-term SWU sale was made between a utility buyer and an intermediary seller. Thirteen near-term EUP sales were reported in 1990, accounting for the balance of slightly over one million SWU and almost seven million pounds equivalent U_3O_8. SWU buyers and sellers were about

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equally split between European and US market participants. Additionally, eight long-term SWU-only purchases, all made by utilities, totalled over 4.5 million SWU for deliveries through 2002; one long-term EUP sale to an Asian utility totalled nearly two million SWU and nearly eight million pounds equivalent U_3O_8 for delivery during the period 1990–1999.

Fundamentally, the SWU market during 1990 was similar to the past several years. Because of the prevalence of long-term requirements-type contracts for enrichment services (particularly the USDOE's Utility Services Enrichment Contract), only a handful of buyers enter the market each year. In the USA, two or three utilities each looking for 100,000-150,000 SWU per reload, and four or five utilities each looking for 20,000-50,000 SWU per reload, can be expected to solicit bids each year. In Europe, where utilities generally have a greater mix of contracts suppliers (Eurodif, Urenco, TENEX, and DOE), demand tends to fluctuate. In an average year, four to six European utilities typically will purchase approximately 50 thousand SWU each. The SWU demand situation should continue until about 1994-1996, when the expiration of DOE's Incentive Price II Proposal could cause some utilities to increase spot-market purchasing, unless DOE makes an attractive Incentive Price III offer in the meantime.

The enriched uranium stockpile of the German Ministry for Research and Technology (BMFT) continued to be sold in 1990, but the pace of the sales varied over the course of the year. The timing and quantity of the sales were partially dictated by BMFT's budget requirements. In 1991, the budget may be increased to meet the needs of the German reunification.

Early in the year, V/O Techsnabexport (TENEX) reported that the Soviet Union had the capability to export up to three million SWU per year, and was eager to conclude both long- and short-term contracts. During 1989, the Soviets shipped significant quantities of enriched uranium to the United States to ensure supplies for their contracted commitments. The stockpiles were stored at fabricators until needed.

Table 8
1990 NUEXCO CONVERSION VALUE

Determined as of the Last Day of the Month	Report Number	Conversion Value	
		Per Pound U as UF_6	Per Kg U as UF_6
January	258	$1.50	$3.31
February	259	$1.50	$3.31
March	260	$1.45	$3.20
April	261	$1.45	$3.20
May	262	$1.45	$3.20
June	263	$1.45	$3.20
July	264	$1.45	$3.20
August	265	$1.45	$3.20
September	266	$1.45	$3.20
October	267	$1.45	$3.20
November	268	$1.45	$3.20
December	269	$1.45	$3.20
1990 Averages [1]		**$1.46**	**$3.22**

[1] Simple arithmetic averages.

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Long-Term SWU Market

The long-term SWU market remained relatively dormant, as many utilities were more interested in reducing the length of their long-term commitments rather than extending them. Five of the nine long-term SWU sales made in 1990 involved TENEX, including a contract with South Korea for the sale of enriched UF_6 enriched at 3.5 w/o U^{235}, equivalent to about 800,000 pounds U_3O_8 and 170,000 SWU per year. The transaction involved countertrade, with the Soviets agreeing to accept 30 percent of the value of the uranium and enrichment services in the form of consumer electronics.

In the USA, TENEX signed four contracts with the Yankee group for the delivery of up to $250 million in enrichment services over the period 1994 to 2002. Several other US utilities requested long-term supply offers in 1990, but none had committed to any purchases by year end.

At least one European buyer concluded a substantial long-term SWU purchase from a primary supplier during 1990. Several other utilities reevaluated their enrichment situations during the year, and long-term market activity is expected to increase in the coming years as contracts are completed and inventories are drawn down. In Asia, most utilities remained well-covered for the long term, under existing supply arrangements.

US Department of Energy (DOE)

The interest in long-term enrichment contracts came from utilities who used their free termination rights with DOE to reduce their commitments under the Utility Services Enrichment Contract (USEC). In an attempt to halt further erosion in its market share, DOE advised all of its USEC customers in February 1990, that the April 1, 1990, deadline for termination notices for FY2000 delivery would be waived for at least one year. DOE customers had until April 1, 1991, to give DOE free ten-year notices of terminations for FY2000 and FY2001 deliveries beyond 30 percent of their requirements, and free five-year notices for termination of 30 percent of requirements in FY1996. Thirty-four DOE customers have exercised their 10-year free termination rights to date.

By waiving the notification deadline for a year, DOE hoped to address the underlying causes for termination prior to any additional customer terminations. However, by the end of 1990, DOE's situation seemed worse: the Atomic Vapor Laser Isotope Separation (AVLIS) program schedule was in jeopardy, DOE was not able to get Congress to pass any restructuring legislation, and DOE had not offered any extension of the Incentive Price (IP) Offers for deliveries in the second half of the 1990s.

Table 9
1990 NUEXCO SWU VALUE

Determined as of the Last Day of the Month	Report Number	(US dollars per SWU)
January	258	$54
February	259	$50
March	260	$50
April	261	$50
May	262	$50
June	263	$50
July	264	$50
August	265	$50
September	266	$50
October	267	$51
November	268	$51
December	269	$51
1990 Averages [1]		**$50.58**

[1] Simple arithmetic averages.

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DOE Operations

DOE was given permission by Congress to purchase the German government's enriched uranium stockpile in FY1990, but declined to do so. DOE again asked Congress for permission to purchase SWU from other sources in FY1991, but Congress decided against legislation allowing outside purchases of SWU until the DOE restructuring issue is resolved. DOE did discuss a possible SWU purchase from the Soviet Union, but the US government's internal review and approval procedures had not reached a decision by year end.

The requirement that DOE purchase below its production cost may have been one of the primary obstacles to any SWU purchase agreements. In response to a customer request for termination charges, DOE indicated that its incremental production costs were in the range of $40 to $45 per SWU, or below current spot market prices. At another time, DOE stated its FY1991 production cost to be about $75 per SWU, creating considerable confusion about its true cost of production. The difference could be explained by DOE's power cost structure: it is able to produce some SWU with non-firm and off-peak power purchased at low rates, but it must also use expensive daytime firm power. The $40 level may represent the cheapest incremental cost and $75, the average incremental cost. Further, DOE's budget provides yet a third cost level: it planned to produce about 12.4 million SWU in FY1991, with announced expenditures of $1.16 billion on gaseous diffusion operations. This translates to an operating cost of about $94 per SWU.

On June 22, 1990, DOE announced that there would be no increase in its base prices for FY1991, maintaining a level of $117.85 per SWU. The incentive SWU price for FY1991 was $100.60 per SWU under the IP II, up from the $90 price of FY1990 under the expiring IP I.

The long-anticipated Clean Air Act became law in 1990, leading DOE to estimate that the Act would increase the cost of enrichment by about $11-15 per SWU by 1997. The cost increases could be attributed to increased pollution controls and to the switch to more expensive low-sulfur coal at coal-burning power plants that provide electricity to the diffusion operations.

As 1990 began, some disputes arose between DOE and a few of its customers over the interpretation of the requirements language in the USEC contract. One area of dispute was whether DOE customers taking 100 percent of their SWU requirements from DOE could deliver enriched feed to their enrichment accounts. The other dispute was whether DOE customers could borrow enriched uranium in order to delay their DOE delivery requirements within a DOE fiscal year. DOE maintained that both practices violated the intent of the contract, even if they were not specifically prohibited.

DOE gave its USEC customers the opportunity to reduce the traditional 180-day notice period for ordering final enrichments and quantities. For enrichments less than 4.5 w/o, DOE customers could define the final enrichments with 150-days' notice, or with 120-days' notice if the customer agreed to accept certain standard enrichments. This was apparently the end result of DOE's attempt to establish the SWUFLEX program. Some other primary enrichers and secondary market sellers also reduced the 180-day lead times in response to customer requests in certain instances.

Smith Barney Report

DOE hired Smith Barney, Harris, Upham, and Co. to perform an independent financial assessment of DOE's enrichment business. Only non-proprietary information from part of the report was released to the public. As expected, the Smith Barney report advocated the privatization of DOE into a corporation that would not be subject to the annual congressional budget process. The report listed a number of benefits for DOE if it were restructured into a government corporation. Smith Barney recommended that DOE purchase SWU from the Soviets in exchange for a limit on Soviet SWU exports to the USA. They also recommended that DOE continue to charge its USEC customers the contractual ceiling price during the period its customers cannot terminate their agreements without penalties, but advised DOE to offer more flexible pricing terms for new and replacement contracts. Smith Barney also predicted that DOE's cost and schedule estimates for AVLIS deployment were optimistic,

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and estimated that a 50-percent increase in the production cost and a 100-percent increase in the capital cost would be more realistic. These forecasted increases would bring the previously projected AVLIS production costs to $75 per SWU for the small plant and $50 per SWU for the large plant (9 million SWU). Smith Barney also stated that the issue of DOE's unrecovered cost was not relevant in today's competitive market; DOE's price should be set by market forces.

Even with the support of its outside consultant, DOE again failed to get restructuring legislation passed in the House. Last-minute proposals to improve the economics of the restructured enrichment enterprise even included a fee of 0.2 mils per kilowatt-hour to be charged to all US nuclear plants, regardless of the source of their SWU. The fees would finance the decommissioning and decontamination of DOE's diffusion plants.

Eurodif

Following renegotiation of its partnership contracts during 1989 and 1990, only two active partners remain, France and Belgium, with Electricité de France (EdF) taking the bulk of Eurodif production. During 1990, EdF substantially reduced its purchases from Eurodif in order to draw down excess stocks. As a result, Eurodif's production was significantly below normal, although the level should stabilize at about two-thirds of capacity in 1991 and for the coming years. Depreciation of the Eurodif plant should result in a lower cost basis for the latter part of the 1990s, assisting the enterprise's marketing efforts, which are handled by Cogema.

A critical report by CEA Administrator General Philippe Rouvillois, completed in 1989, but made public in 1990, called for the reorganization of the French fuel cycle and questioned the viability of SILVA (same as AVLIS technology). The report questioned SILVA and the CEA's methods for funding R & D in technology, and caused a reevaluation of the program. Mr. Rouvillois believes that industry should fund the R & D that supports its operations.

The lawsuit between Eurodif and Iran, an original shareholder in Eurodif through a company called Sofidif, still has not been resolved, despite a ruling from an international tribunal of the Chamber of Commerce. The tribunal awarded Iran $180 million as partial payment in the lawsuit. Other related lawsuits have not yet been resolved, and a potential payment of over $1 billion to Iran may ultimately be required, creating a huge financial liability for Eurodif, and uncertainty among Eurodif partners about their potential financial exposure.

Urenco and Louisiana Energy Services (LES)

During 1990, Urenco operated close to full capacity of 2.5 million SWU per year at its three enrichment plants, located at Capenhurst, UK; Almelo, The Netherlands; and Gronau, Germany. Capacity expansion is expected to be limited in the coming years until prospects for increased market share are clarified. Urenco's centrifuge plant allows for modular capacity additions. At the moment, Urenco is focusing its expansion efforts in the USA through LES.

Congress passed legislation on October 27, 1990 that allowed the LES centrifuge enrichment facility to be licensed under the regulations for fuel cycle facilities (*10CFR, parts 40 and 70*) instead of the reactor licensing regulations (*10CFR, part 50*). Use of the fuel cycle facilities regulations greatly reduces the financial risk in constructing such a facility, since the operating licensing would be received prior to, rather than after, construction expenditures.

LES is a formal partnership, with Urenco owning about 47 percent of the company, Duke Power holding 29 percent, Fluor Daniel 13 percent, Northern States Power 7.4 percent, and Louisiana Power and Light 4.6 percent.

The LES centrifuge plant is planned to have an annual capacity of 1.5 million SWU at a cost of $750 million, that will reach $1 billion, including financing costs, by the time the plant begins operation in 1996. Using a relatively low capital cost recovery factor of 10 percent per year, the LES capital cost per SWU would be about $70 per SWU, and the operating costs could be about $30 per SWU.

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NEW ENRICHMENT TECHNOLOGIES

AVLIS

In January 1990, DOE released a multifaceted plan for the commercial deployment of the AVLIS technology. The plan called for several steps:

- Continued technical development leading to critical demonstration tests of a commercial-scale separation system would begin in March 1992 and end by September 1992.
- DOE would select a list of potential commercial sites by December 1990, and make a final site selection by November 1992.
- DOE would also select a commercial deployment contractor (CDC), to which DOE would transfer the AVLIS technology. The CDC would be responsible for design, construction, and operation of the AVLIS commercial facilities.
- DOE was to issue a request for proposals from potential CDC's in September 1990, transfer the technology through an industrial access program, and make a final selection by September 1991.
- DOE was to apply for an NRC license by March 1991, and receive a license by March 1993.

DOE set November 1992 as the date for a decision about the commercial deployment of AVLIS, that would lead to completion of the first commercial facility in 1997.

DOE announced the results of scoping studies for the first commercial facility, which showed that a three million SWU-per-year plant would have a capital cost of $600 million and an annual operating cost of $70 million. Doubling the plant size would increase the capital cost to $800 million with an operating cost of $130 million, while a nine million SWU-per-year facility could be built for $1 billion and have an annual operating cost of $170 million. Assuming a capital cost recovery factor of 10 percent per year, the estimated AVLIS costs would range from about $43/SWU for the smallest plant to $30/SWU for the largest, excluding recovery of development or decommissioning costs.

At the end of 1990, the AVLIS technical program seemed to be on track, but progress on AVLIS deployment had come to a halt. DOE's request for proposals for a CDC had not been issued. The Nuclear Regulatory Commission (NRC) informed DOE that it had no authority and no budget to license a DOE facility. It appears that even limited deployment funding may be cut from DOE's FY1992 budget, signaling a major delay in the AVLIS program.

CRISLA

On August 20, 1990, Isotope Technologies announced it had formed a Canadian joint venture, called CRISLA Technologies, with Cameco and Agra Industries (a large Canadian architectural-engineering firm). Further research and development will continue at Cameco's laboratories in Saskatoon, where CRISLA Technologies plans to build a commercial-scale separation module by the end of 1991

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URANIUM PRODUCTION

Western World uranium production continued its downward trend, dropping 12.9 percent, to 74.5 million pounds U_3O_8 in 1990. Over 90 percent of this 14.8 million pound decline is attributable to production decreases in Canada, South Africa, France, and the USA. Although Western production declined in 1990, uranium exports from eastern Europe and China to the Western market nearly tripled; approximately 10.7 million pounds equivalent U_3O_8 in exports entered the Western market in 1990 (**Table 10**).

Canada

For the seventh consecutive year, Canada was the world's largest producer of uranium. Nevertheless, 1990 output dropped by 7.4 million pounds, to 22.0 million pounds U_3O_8. A significant decrease in production was recorded in Saskatchewan, where the Rabbit Lake mill remained closed throughout the year. Significant decreases were also recorded in the Elliot Lake region of Ontario, as Denison reduced its production rate by about 40 percent, and Rio Algom closed both the Panel and Quirke operations. Despite low levels of exploration and development activity during 1990, Cameco announced the discovery of a high-grade uranium deposit at the McArthur River prospect.

USA

In 1990, production dropped sharply in the USA, down 26.1 percent to 10.2 million pounds U_3O_8. This is the lowest level of US uranium production since 1955. Conventional and mine-water production accounted for 58 percent of the total; phosphate by-product, 27.6 percent; and in-situ leaching (ISL), 14.4 percent. Energy Fuels was the largest US uranium producer, with an output of 2.5 million pounds U_3O_8 in 1990. Uranium Resources Inc.'s (URI) Rosita ISL project came on-line in September, but seven other projects shut down during the year, including URI's Kingsville Dome ISL project, conventional and mine water production at Homestake Mining's Grants operation, Chevron's Mt. Taylor mine, Malapai's El Mesquite and Irigaray/Christensen ISL projects, UMETCO's Colorado Plateau uranium/vanadium operations, and TOTAL's West Cole ISL project.

Australia

Australia's uranium production remained relatively stable at 9.1 million pounds U_3O_8, down 4.2 percent from 1989. The present uranium policy continues to limit production to three approved producers: Queensland Mines at Nabarlek, ERA at Ranger, and the Western Mining Corporation-British Petroleum joint venture at Olympic Dam. Since Queensland Mines finished milling the Nabarlek ore in 1988, all output in 1990 was again from the Ranger and Olympic Dam projects. Review of the "three-mine policy" is currently scheduled for this summer's biennial Australian Labor Party convention.

Namibia

Output from the Rössing mine, Namibia's sole uranium operation, remained at 8.0 million pounds U_3O_8 for 1990. This output level represents approximately 80 percent of Rössing's annual production capacity.

Niger

Production from Niger's Akouta and Arlit mines remained relatively stable, decreasing only 3.9 percent, to 7.4 million pounds U_3O_8 in 1990.

France

Uranium production dropped 11.9 percent in France, to 7.4 million pounds U_3O_8. The majority of this decrease was due to the closure of at least two of the four mines operating at Cogema's Vendee Division in western France. Cogema plans to close the remaining mines at Vendee by the end of 1991.

South Africa

South African uranium production continued to decline, dropping 16.9 percent, to 6.4 million pounds U_3O_8 in 1990. Nearly half of this decline is attributable to the closure of Anglo American's Joint Metallurgical Scheme; over one quarter is attributable to reductions at South Africa's largest uranium project, Vaal Reefs. Further declines are expected, as Anglo American has announced the closure of its ERGO uranium plant by April 1991.

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Gabon

Output from the Mounana project totaled 1.8 million pounds U_3O_8. This represents a 21.7 percent decline from Gabon's 1989 production level of 2.3 million pounds.

Eastern Europe and China

Uranium exports from eastern Europe—including the Soviet Union, eastern Germany, Czechoslovakia, Hungary, Bulgaria, and Romania—to the Western market, totalled 8.6 million pounds U_3O_8 in 1990, more than five times the volume exported in 1989. Of these east European countries, the Soviet Union has been the leader in both production and exports to the Western market. After WWII, the Soviet Union controlled uranium production in all of its former satellite countries. All production was shipped to the Soviet Union, where a substantial stockpile has now accumulated. Of the former Soviet satellites, East Germany and Czechoslovakia were the major uranium producers. Many of their mines, however, are high cost, and will be closed in the near term.

Exports from China to the West remained relatively stable in 1990, at 2.1 million pounds U_3O_8.

Other

Production continued at steady levels in most of the smaller uranium-producing countries, including Belgium, India, Portugal, and Spain. In order to increase both production and recovery, Spain has initiated the development of a new conventional milling facility at Saelices el Chico. Recent closures resulted in production decreases in Argentina and Pakistan. Argentina's Los Gigantes project was closed near the end of 1989; output during 1990 was from the Sierra Pintada and La Estela projects. Early in the year, Pakistan shut down its only uranium mine for four months as a result of localized fighting.

Uranium production is also being terminated in Yugoslavia, western Germany, and Brazil. During 1990, the Slovenian government began the process of closing Zirovski Vrh, its only uranium mine. Economic reasons were cited for the closure. Environmental concerns resulted in the closure of western Germany's sole uranium operation at Ellweiler. In addition, Uranio do Brazil plans to phase out production at the Pocos de Caldas project, while shifting its uranium production operation to the higher-grade Lagoa Real site within the next few years.

Table 10
URANIUM PRODUCTION AND EXPORTS – 1985-1990 [1]

	Production and Exports (Million Pounds Equivalent U_3O_8)						1990 Relative	Market Share [2]	
	1985	1986	1987	1988	1989	1990	to 1989	1985	1990
PRODUCTION:									
Australia	8.4	10.8	9.8	9.3	9.5	9.1	– 4.2%	9.3%	10.7%
Canada	28.3	30.5	32.3	32.4	29.4	22.0	– 25.2%	31.3%	25.8%
France	8.3	8.5	8.7	9.0	8.4	7.4	– 11.9%	9.2%	8.7%
Gabon	2.4	2.2	2.1	2.4	2.3	1.8	– 21.7%	2.7%	2.1%
Namibia	8.8	9.0	9.2	9.1	8.0	8.0	0.0%	9.7%	9.4%
Niger	8.3	8.2	7.3	7.7	7.7	7.4	– 3.9%	9.2%	8.7%
South Africa	12.7	12.0	10.3	9.9	7.7	6.4	– 16.9%	14.1%	7.5%
USA	11.1	13.1	12.4	13.4	13.8	10.2	– 26.1%	12.3%	12.0%
Other [3]	2.0	2.1	2.4	2.4	2.5	2.2	– 12.0%	2.2%	2.6%
EXPORTS:									
Eastern Europe [4] & China	0.0	0.4	0.6	1.3	3.6	10.7	+197.2%	0.0%	12.6%
Total	**90.3**	**96.8**	**95.1**	**96.9**	**92.9**	**85.2**	**– 8.3%**	**100%**	**100%**

[1] Figures presented are NUEXCO's best estimates.
[2] Expressed as a percentage of total production.
[3] Includes Argentina, Belgium, Brazil, India, Pakistan, Portugal, Spain, western Germany, and Yugoslavia.
[4] Includes only that portion of production and inventory exported to Western countries.

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EXPLORATION AND DEVELOPMENT

OVERVIEW

While the field work necessary to locate new uranium deposits was limited worldwide in 1990, some programs did proceed and several events occurred that will shape the course of future exploration. The two most important events affecting exploration were the establishment of a single worldwide market, and historically low spot market prices. The commodity that began the post-World War II era as very scarce, very expensive, and very regulated, is now relatively plentiful and cheap, but still well-monitored. The Cold War of the last 45 years melted in 1990, breaking down many national and regional barriers and causing uranium to become a truly international commodity. Unfortunately for the prospector and miner, the cheapest short-term source of uranium is not the lowest-cost deposit, but warehouses where the excess inventories of utilities, producers, and nations, are stored.

Although an increasing amount of data is becoming available about the uranium industries of eastern Europe, the Soviet Union, and China, many details of geology, production, and costs are still incomplete. It is very apparent, however, that the Soviet Union, China, Germany, Czechoslovakia, and Hungary have exploited a number of major deposits, and that these countries have significant remaining resources to be considered in any analysis of future long-term uranium supply. Exploration geologists in this new worldwide uranium industry need to understand these deposits and to employ that knowledge as an additional tool in the search for further resources.

In the world outside centrally planned economies, there is a concentration of both production and ownership. The nations with the largest production in 1990 were Canada, the USA, and Australia. In total, these countries provided over 50 percent of Western World production. When France, Namibia, and South Africa are added, the share is over 80 percent. This same concentration applies to the firms who own the deposits, operate the mines, and take the lead in looking for new deposits. Three firms, each with about 15 percent of world production (Cameco, Cogema and RTZ), are large, well-staffed firms. When the eight next-largest companies are added, about 80 percent of world production is covered.

NORTH AMERICA

The North American continent has historically been considered the largest uranium producing and exporting area in the world. Despite the effects of record low market prices, uranium exploration continues, as evidenced by some exploration and definition drilling, and assessment drilling.

Canada

Cameco, operator of Key Lake, the largest uranium production complex in the world, has an ongoing, but limited, exploration program. In 1990, this program consisted of less than 50 holes, but defined a 200 million pound, high-grade U_3O_8 deposit at McArthur River in the Athabasca Basin of northern Saskatchewan (**Figure 5**). This deposit is only 40 miles northeast of the existing Key Lake mill complex and will provide the resources for processing at Key Lake well into the twenty-first century.

Further north, Denison Mines Ltd. completed its test mining program at the Midwest project during 1989. In 1990, Denison removed its equipment from the site and allowed the mine to flood. The test mining was a technical success, with the extraction accomplished using large diameter holes (48 inch) drilled from mine workings just above the deposit. The economic implications of the tests are still being studied and have not yet been announced. Denison is undergoing a corporate reorganization and a financial crisis that may delay any further activity at the project.

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Figure 5
Major Exploration & Development Projects, and Mines, of the Athabasca Basin

In the same area, Minatco, a subsidiary of TOTAL of France, acquired full ownership of the McClean Lake project, now renamed the Wolly Project. Feasibility work has been started and permitting activity could start in 1991. Newly-defined zones north and east of the main McClean Lake occurrence likely will be mined first, using open pit techniques, while the 160-meter-deep McClean deposit is considered an underground site.

A few hundred miles to the northeast, near the west shore of Hudson Bay, is the Thelon Basin, which is very similar geologically to the Athabasca Basin. In 1990, several firms were active to some degree in the district: Urangesellschaft (UG) of Germany, PNC Exploration (Canada) Co. Ltd. (a subsidiary of the Japanese Company, Power Reactor and Nuclear Fuel Development Corporation), and Power Resources Inc. (formerly CEGB Exploration, Inc. of the United Kingdom). The most active company in the Thelon Basin has been UG. Over a period of eleven years, UG plans to exploit the Kiggavik Project's 45 million pounds of reserves from two open pits. But, this project has several factors slowing its progress, including poor market conditions and Native American land claims in the area. Consequently, UG has recently withdrawn its permit application for the project.

United States

During 1990, five firms performed the bulk of exploration/feasibility work in the USA: Uranium Resources Inc. (URI), Power Resources Inc. (PRI), TOTAL Minerals, Ferret Exploration of Nebraska, and UP Resources. Notably, only UP Resources was working on a conventional mining project; all of the others were pursuing in-situ leaching (ISL) projects.

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URI has two projects located in South Texas. URI initiated production at its Rosita Project at a rate of about one million pounds U_3O_8 per year, while it maintained a similar annual capacity on standby at Kingsville Dome. The company continues to examine other targets, mainly in the Goliad Formation, the host for both Kingsville Dome and Rosita. URI also has two projects in New Mexico, Churchrock and Crown Point, with total recoverable resources exceeding 25 million pounds U_3O_8, and is making significant progress toward permitting these two projects.

PRI is a wholly owned subsidiary of the UK utilities Nuclear Electric plc and Scottish Nuclear Ltd. In late 1990, PRI was successful in acquiring the Gas Hills properties of the Tennessee Valley Authority. This acquisition expands PRI's reserve base in central Wyoming to over 40 million pounds U_3O_8.

For most of the year, UP Resources continued drilling in northern Arizona with two rigs. This program, a joint venture of UP Resources and Taiwan Power, is exploring and evaluating breccia pipe deposits. The joint venture announced in 1990 that the Sage deposit was ready for development.

In 1990, Electricité de France (EdF) formed a new US-based subsidiary named Fuel International Trading Corporation (FITCO). In cooperation with TOTAL Minerals, a subsidiary of Total Compagnie Française des Petroles, FITCO acquired, through a complex transaction, the uranium-related assets of Malapai Resources. TOTAL Minerals is the operator of the Malapai project. This acquisition gives FITCO significant resources and ISL production facilities both in Texas and Wyoming. These facilities, in combination with TOTAL's operations (the West Cole project and a 45 percent interest in the Rhode Ranch open-pit mine), give FITCO access to production capacity of several million pounds per year. Actual production in 1990 was about 1.5 million pounds equivalent U_3O_8. One new ISL project, Alta Mesa, is in the permitting phase in Brook County, Texas.

Ferret Exploration is operator and part-owner of the Crow Butte ISL Project in northwest Nebraska. Well field development has been completed and the plant is nearly finished. Start-up is scheduled for early 1991 at a rate of 500 thousand pounds per year with full capacity of one million pounds per year not expected until the market improves. Limited drilling has continued the definition of the main Crow Butte trend to the north. Additionally, a second trend, Three Crows, has been defined about ten miles west of the new plant. Some drilling has also been conducted on the Big Red deposit, south of the plant.

Other notable uranium activities in the USA involved Kennecott Corporation, Rio Algom Mining Corporation, and Uranerz USA Inc. Kennecott, a subsidiary of the British corporation RTZ, purchased a 50 percent interest in the Green Mountain, Wyoming project from US Energy. The joint-venture partners are evaluating alternative mining techniques for this deep deposit in the Battle Spring formation. Rio Algom, also a subsidiary of RTZ, is in the process of permitting its Smith Ranch, Wyoming, ISL project for a proposed capacity of two million pounds per year. Also in 1990, Uranerz received NRC permits for its Ruth and North Butte ISL projects.

North American Drilling Statistics

The average drill count in the USA was about ten per month in exploration and fourteen per month in development. About twice as many rigs operate during the summer and fall, compared to winter and spring. In Canada, the reverse is true, with two-thirds of the drilling done in the winter when the ground and lakes are frozen. During the winter of 1989–1990, the maximum rig count reached fifteen in both the USA and Canada. This surface exploration effort was augmented with an average of five to ten underground drills operating throughout the year.

In both Canada and the USA, funding for exploration comes increasingly from foreign investors. This event has been generally welcomed by industry and government, and is reflective of the worldwide market that has developed.

AUSTRALIA

Uranium exploration and development continues at very low levels due to the Australian government's prohibition on new mine development. This three-mine policy is planned for review by the ruling Australian Labor Party (ALP) at its biennial convention this summer. The ALP may be softening its stance on this issue, but the outcome of any review, if it does indeed occur, is far from certain.

Nevertheless, increasing interest in Australian uranium by foreign firms is evident on several fronts. The German firm, Degussa, increased its share in Pancontinental to 14 percent.

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Pancontinental is the owner/optionee of the huge Jabiluka deposit. Cogema (France) also increased its share of Jabiluka to 14.9 percent, the maximum allowed without approval of the Australian government. Cogema is also negotiating for exploration rights to Queensland Mines land holdings in the Nabarlek area.

CRA Ltd., a subsidiary of RTZ, continues to explore, define, and evaluate its Kintyre deposit in Western Australia. The deposit has more than 75 million pounds of potentially exploitable uranium. Energy Resources of Australia completed exploration of the Ranger project area, but no significant additional mineralization was found and the exploration program has been discontinued.

EUROPE

Five west European companies, including Cogema, TOTAL, RTZ, Uranerz, and Urangesellschaft, are major participants in the worldwide uranium industry. These five firms have various ownership and operational interests in projects that, together, produced over fifty million pounds U_3O_8 during 1990. This production represents nearly 70 percent of the Western World's 1990 output.

In Spain a long-awaited conventional mill is being built at Saelices el Chico. This plant will replace and expand the current heap leach operation, and will justify further exploration and development in this district. However, actual exploration work in France and Germany was down substantially from past levels. Much of the staff and equipment have shifted to environmental work or to other mineral commmodities. France, which has had a strong domestic evaluation effort for many years, has reduced that program significantly.

While uranium has had a long public history in western Europe, the same has not been true of eastern Europe and most of Asia. With the end of the Cold War, the situation has changed. While details of past production, current operations, and future potential are still incomplete, the information available indicates that this area of the world will play a major role in the front end of the nuclear fuel cycle in the future.

The structure of mineral industries in centrally planned economies is much different from that in market economies. In the former East Bloc countries, the professional staff has been large, and both the scale and depth of its exploration programs have been substantially greater than most Western programs. While actual field work was at low levels in 1990, large competent organizations exist in this part of the world. These groups are, however, beginning to reduce their size, and to shift to mineral commodities other than uranium. Eastern Europe has a large resource of people, equipment, and experience in the uranium exploration field.

In the Soviet Union, uranium exploration and production have had high priority in the past, but only as part of large regional and integrated multi-mineral programs. As priorities change, however, many production centers may be directed to shift to other areas.

Not many years ago, each major nation had its own government agency to support the search for uranium. Today, the institution of note is the United Nations' International Atomic Energy Agency (IAEA) in Vienna, Austria. As various national entities have lost funding, interest, or capability to effectively monitor and promote their respective uranium industries, the work of the IAEA has become increasingly important. It provides data collection, technology transfer, and accurate publication of much of the world's uranium industry information.

ASIA

China

In China, extensive work is being done in detailing known uranium resources and potential. There are at least five thousand people working in this industry segment and thousands more in mining and processing. These employment numbers far exceed those for the whole uranium industry of the Western World. But, in China, as in the rest of the world, there is an ongoing shift from uranium to other commodities. China is rich in natural resources and will be a factor in the long-term uranium market, as well as in many other mineral markets.

India

India maintains a large, ongoing program of uranium exploration and development aimed at fulfilling internal needs. The new Turamdih mine is under development to replace deep, low-grade production at nearby Jadaguda.

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AFRICA

Throughout Africa, there has been a significant slowdown in uranium exploration. No major programs outside existing production centers were conducted in 1990. Some work was done by foreign investors, but only enough to keep their leases open. In South Africa, very few resources were devoted to uranium exploration. Several marginal uranium operations have been shut down, and more cutbacks and closures are likely, even among major producers such as Vaal Reefs. With no increase in price, no change in exchange rates, and limited access to world markets due to apartheid sanctions, uranium production in South Africa could cease almost entirely within a few years.

Namibia became independent in March 1990 and sanctions were lifted shortly thereafter. Uranium from the Rössing deposit now has unencumbered access to world markets. Namibia and Rössing would likely increase exploration and development if market conditions improved. The new government of Namibia has indicated it may take a larger role in the operation of Rössing, but as yet no major changes have occurred.

Uranium exploration in Gabon and Niger is conducted by several groups. Cogema is the primary force, and is joined in its efforts by various entities including the governments of Gabon and Niger, Urangesellschaft, Comuf, Korea Electric Power Company, and Overseas Uranium Resource Development Corporation.

OTHER

Uranium exploration has all but ceased in most other areas of the world, since neither price nor the pace of nuclear power development provides any incentive. Brazil is the only country where any development activity is occurring; the country is evaluating new production sources as a replacement for the disappointing Pocos de Caldos project.

Periodically, some limited information concerning uranium exploration and development in other countries becomes known. Iran, for example, maintains an ongoing program of uranium exploration and periodically announces plans for construction of new production centers, but no information emerges as to actual production. North Korea is known to have conducted some uranium exploration. Major contributions to world supply from such possible sources are unlikely.

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GABON

Uranium production from Gabon's two uranium mines, Oklo and Boyindzi, totalled 1.8 million pounds equivalent U_3O_8 during 1990. That 20 percent drop from the 1989 output of 2.25 million pounds resulted from the mining of lower-grade ore. Output in 1991 is not expected to change significantly from the 1990 levels. Gabon's uranium output is exported by way of the terminal at Owendo, located near Gabon's capital of Libreville. Nearly 70 percent of the country's production is exported to France.

Compagnie des Mines d'Uranium de Franceville (Comuf), a consortium owned 75 percent by French entities and 25 percent by the Gabonese government (**Table 11**), owns and operates both mines and the Mounana mill, where the ore is processed. The Mounana mill has an annual capacity of about 4.3 million pounds equivalent U_3O_8.

Table 11
COMUF OWNERSHIP

Gabon Government	24.8%
Compagnie Française de Mokta	39.0%
Cogema	18.8%
Uranium Pechiney	10.6%
Cofirmer	5.8%
Gabonese Individuals	1.0%
Total	100%

The Gabonese government participates in all facets of the economy, but through a policy of economic liberalism, encourages foreign investment. Gabon's membership in the Franc Zone gives its trading partners confidence in the country's currency. The CFA (Communauté Financière Africaine) franc is convertible to French francs at a fixed rate. Gabon's government provides various tax incentives for uranium exploration, and a couple of groups conduct exploration activities in Gabon: the Franceville-South Joint Venture, which is a consortium of Cogema, the Gabonese government, Urangesellschaft, and Comuf; and the Leyou-North Joint Venture, which includes Cogema, the Gabonese government, and Korea Electric Power Company (KEPCO). Comuf also explores independently.

Gabon's uranium production costs substantially exceed current spot market price levels, but higher prices for deliveries to French buyers subsidize the continued operation of Comuf's otherwise uneconomic facilities. Although Gabon does not depend on uranium exports as its primary source of foreign exchange, those exports do make important contributions to domestic employment and the country's balance of payments. Also, France's foreign policy aims to maintain its historically influential role in Gabon, a former colony. Therefore, any decision to reduce the quantity or price of French uranium purchases from Gabon, however logical economically, must first give serious consideration to their political implications.

NAMIBIA

Production from Namibia's only uranium operation, the Rössing project, remained level at 8.0 million pounds equivalent U_3O_8 during 1990, unchanged from 1989's output. Namibia became an independent nation on March 21, 1990. Shortly after its independence, most nations of the world lifted anti-apartheid sanctions, thereby giving Namibian uranium open access to world markets.

Rössing, despite sanctions, continued until 1989 to produce near its annual capacity of ten million pounds in order to maintain its reputation as a reliable supplier and to retain its skilled work force. Current market conditions have led Rössing Uranium Ltd. to produce at only 80 percent of capacity for the past two years. Additionally, Rössing management announced in early 1991 that production would be cut an additional 20 percent as of April 1991. The cuts are a result of loss of customers due to sanctions, but Rössing's prospects for securing new long-term contracts have improved following Namibian independence. In fact, Rössing reached its first long-term agreement with a US utility in the second half of 1990.

Namibia's government is led by Sam Nujoma, the nation's new president, and leader of the South West Africa People's

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Organization (SWAPO). In the elections held in November 1989, the left-wing SWAPO won a clear majority of seats in the constituent assembly, but fell short of the two-thirds majority that would have allowed the Party to take complete control and write its own constitution. By December 1989, the assembly had agreed in principle to a constitution based on a multi-party democracy similar to the outline established in a 1982 supplement to United Nations (UN) Resolution 435. The constitution was approved by the constituent assembly and ratified by the UN Security Council in early 1990.

Although a UN report in 1989 disclosed that the large foreign ownership of the mining industry resulted in a considerable outflow of Namibia's wealth, SWAPO has determined that nationalization of the mining industry could jeopardize the country's economy. The new government has only a 3.4 percent ownership share in Rössing, but has a 51 percent voting share and, therefore, the major influence in how the project is operated. The UK's RTZ Corporation handles the marketing and sales of Rössing's uranium.

RTZ effectively owns 46.5 percent of Rössing (RTZ owns 41.4 percent directly, and also owns 51.3 percent of Rio Algom, which owns 10 percent of Rössing).

NIGER

Niger's uranium production totalled 7.4 million pounds equivalent U_3O_8 during 1990. That figure represents a modest decline of four percent from the 1989 output of 7.7 million pounds. Two uranium projects operate in Niger, Akouta and Arlit, and both are largely controlled by French entities. The Akouta facility produced approximately 4.8 million pounds, and Arlit, the balance. Production is expected to remain relatively stable in 1991.

Akouta, the largest underground uranium mine in the world, is owned by Cominak (Compagnie Minière d'Akouta, **Table 12**) a consortium of Cogema; Onarem (Office Nationale des Ressources Minières), the state-owned mineral resources company; Japan's Overseas Uranium Resources Development Company (OURD); and Enusa, the Spanish fuel-cycle company. Cogema takes about half of the mine's output, with the balance going to Spanish and Japanese interests.

Table 12
COMINAK OWNERSHIP

Cogema	34%
Onarem	31%
OURD	25%
Enusa	10%
Total	100%

The Arlit project, which is based on a series of open-pit mines, is owned by Onarem (33 percent); Cogema (27 percent); Compagnie Française Mokta, a subsisidary of Cogema (19.4 percent); Uranium Pechiney (7.6 percent); Italy's Agip S.p.A. (6.5 percent); and Urangesellschaft (6.5 percent).

Production shifted from the three Arlit deposits to the nearby Taza deposit in 1988. The Taza deposit offers a lower stripping ratio and a higher grade ore. Onarem, Cogema, and the Kuwait Foreign Trade and Construction Company own equal shares of the Taza deposit.

Uranium Exports

The export to France of uranium produced in the Air region is of vital importance to the economy of Niger. As a result, variations in the level of the French nuclear power program's annual purchases from Niger can have a significant impact on Niger's economic outlook. Niger's economic prosperity in the late 1970's was primarily due to uranium revenues. As recently as 1986, uranium revenues accounted for 80 percent of Niger's export earnings.

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SOUTH AFRICA

Uranium Production

By-product uranium production in South Africa continued to decline in 1990 to approximately 6.4 million pounds equivalent U_3O_8, a drop of 17 percent from the 1989 total of 7.6 million pounds. South Africa's share of the uranium market has declined significantly over the last seven years (**Figure 6**) due to sanctions, increased costs, and low gold and uranium prices. Sanctions also have had an adverse effect on Nuclear Fuels Corporation of South Africa Pty. Limited's (NUFCOR) success in concluding or extending utility supply contracts. NUFCOR, the organization responsible for marketing South African uranium, has been limited by both the sanctions and market conditions. NUFCOR has relied traditionally on higher-priced, long-term contracts for the majority of its sales, and therefore has hesitated to enter the lower-priced spot market for fear of hurting its position when negotiating long-term contract prices.

Policy changes by South Africa's government may lead to the lifting of sanctions in 1991, which could result in increased production. This is unlikely, however, as all uranium produced in South Africa is recovered as a by-product of gold ore processing, except at Palabora, where uranium is recovered as a by-product of copper mining. Consequently, uranium production has been hampered by weak gold prices and low uranium spot market prices, both in rand and dollar terms.

The 1990 decline in South African production is due largely to the shutdown of Freegold's Joint Metallurgical Scheme (JMS) operation. The decline is also due to a drop in production from East Rand Gold and Uranium Company, Ltd. (ERGO) and reductions at Vaal Reefs and Palabora. Only Western Areas showed on increase in 1990 production, primarily due to an increase in ore grade (**Table 13**).

Freegold, once South Africa's second largest uranium producer, ceased production in the fourth quarter. Following the March 1990 shutdown of the JMS, Freegold tested the feasibility of using higher-grade feedstock, but this also proved uneconomic and resulted in halted production during the third quarter of 1990.

ERGO will also close down its uranium operations in April 1991. After continuous decreases in quarterly production rates, ERGO announced that uranium production from its flotation plant was no longer economically viable.

South Africa's largest uranium producer, Vaal Reefs, announced that production at its western uranium plant has been reduced by 50 percent, also due to economic difficulties. In addition, Vaal Reefs suspended production at its eastern uranium plant until economic conditions improve.

Figure 6
South Africa Uranium Production
1980–1990

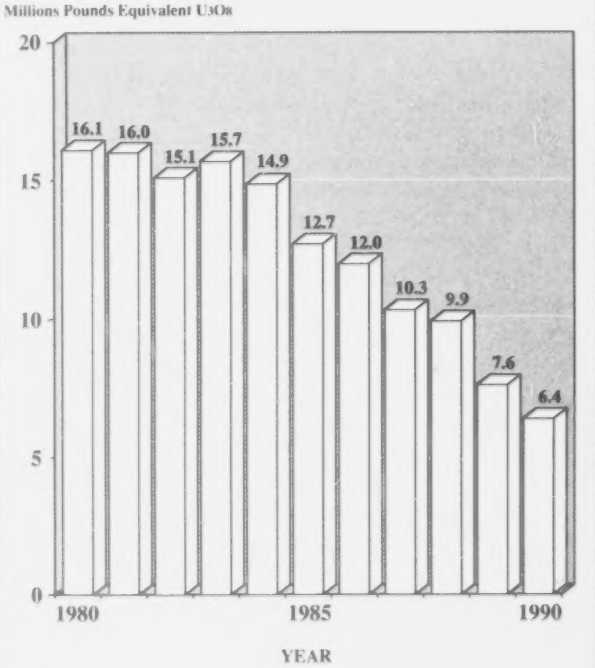

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Table 13
SOUTH AFRICAN URANIUM PRODUCTION BY MINE (1989-1990)

MINE	1989	1990	Percent Change [1]
Operating:			
Buffelsfontein	856	699	- 18.3
ERGO [2]	382	213	- 44.2
Hartebeestfontein	759	725	- 4.5
Vaal Reefs	3,935	3,575	- 9.2
Western Areas	496	579	+16.7
Palabora	244	200	- 18.0
Closed:			
Freegold [3]	978	368	- 62.4
Total [4]	**7,606**	**6,359**	**- 16.9**

[1] Change in percent from the 1989 total.
[2] ERGO=East Rand Gold and Uranium Company Ltd.
[3] Formerly Free State Joint Metallurgical Scheme.
[4] Columns may not add up due to independent rounding.

Hartebeestfontein's 1990 production level declined gradually throughout the year, ending the year with a production level of 725 thousand pounds equivalent U_3O_8, a decrease of only 4.5 percent. Hartbeestfontein loses money when producing uranium because it uses the more expensive process of reverse leaching. The higher recovery costs are not covered by uranium revenues. Using this process, however, enhances the subsequent recovery of gold, and the loss from uranium production is compensated for by increased gold yields.

Nuclear Power Program

Koeberg, built by Framatome, is South Africa's only nuclear power station. Its two 920 MWe pressurized water reactors produced 8,943 GWh (gross) with an average capacity factor of 53 percent for 1990. Construction of additional nuclear generating capacity is being considered.

South Africa's semi-commercial scale helikon uranium enrichment plant at Valindaba was commissioned in 1988. In April 1990, the Atomic Energy Corporation of South Africa Ltd. (AEC) announced that the first reload of fuel produced at Valindaba was loaded into Koeberg-2. Valindaba's annual capacity of 300 thousand SWU will meet all the fuel requirements of South Africa's nuclear power program for at least this decade, and as much as one third of the capacity could be exported.

South Africa has not signed the Treaty on the Nonproliferation of Nuclear Weapons (NPT), although it will probably do so soon in response to increasing international pressure. Members of the International Atomic Energy Agency have threatened to expel South Africa unless it signs the NPT. In response, the government of South Africa has made it known that it will sign the NPT if other states in the region do so. As further proof of South Africa's intentions, locally produced fuel falls under IAEA full-scope safeguards as soon as it enters the boundary of the Koeberg station.

Political Developments

1990 was characterized by continued domestic protest in South Africa, but international economic and political pressures eased during the year. In spite of domestic upheaval within the country, South African President F. W. de Klerk has managed to make sufficient progress toward ending apartheid such that some nations are calling for easing, or even lifting sanctions against the country. Portugal and Italy called for a worldwide lifting of sanctions, and Britain lifted its ban on new investment in South Africa. After further changes in South Africa toward a multi-racial democracy such as the release of Mandela and President De Klerk's promise to end legally sanctioned racial segregation, the European Community lifted its voluntary ban on investment in South Africa.

Although studies have demonstrated that sanctions failed to deny South Africa access to markets and vital commodities such as oil, economic sanctions have imposed tremendous economic penalties on South Africa. A study by the US-based Investor Responsibility Center found that sanctions have cost South Africa's economy US$15 billion to US$27 billion. Anti-apartheid sanctions have been primarily *de facto* rather than *de jure*, with the USA being the only nation to impose legislative sanctions.

In spite of many obstacles, the South African government is making progress toward a non-racial, democratic society. This progress is especially evident in De Klerk's February 1, 1991 announcement that the Land Acts and Group Areas Act had been repealed, and promise that the

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Population Registration Act would be phased out. The Group Areas Act segregated black and white residential areas, and the Land Acts barred blacks from owning land outside specially designated areas. The Population Registration Act, the most controversial of laws, forces South Africans to register by racial group for economic and political purposes. The time line shown in the accompanying box lists noteworthy events in recent South African history.

President De Klerk will have met four of the five main conditions of the USA's Comprehensive Anti-Apartheid Act of 1986 once his February 1, 1991 announcements are implemented. At that time, US President Bush is empowered to begin lifting sanctions, though the administration has pledged to lift sanctions only after consulting with Congress. Japan, South Africa's second largest trading partner, stated that it would maintain sanctions as long as the United States does.

The issue of an estimated 1,000 political prisoners presently being held in South Africa remains an issue for the lifting of US sanctions. South African President De Klerk also has not lifted the government's State of Emergency order in the Natal province.

South African Time Line

August 15, 1989—F.W. De Klerk becomes acting president, following the resignation of P.W. Botha.

September 6—National Party retains power by slender margin in parliamentary elections. De Klerk asserts that results give him a "clear and resounding mandate" to push ahead with plans for evolutionary change.

October 15—Walter Sisulu and five other African National Congress (ANC) activists released from prison.

February 2, 1990—De Klerk announces legalization of the ANC, the South African Communist Party, and the Pan-Africanist Congress, and lifts restrictions on 33 other opposition groups.

February 11—Nelson Mandela released after more than 27 years in prison.

May 2-4—"Talks about Talks." De Klerk and Mandela lead government/ANC talks on obstacles to negotiations about a new non-racial constitution.

June 7—De Klerk lifts state of emergency, renewed annually by the government since 1986, in all areas except Natal province, still plagued by politico-tribal violence between supporters of Mandela's ANC (primarily Xhosa tribe) and Chief Buthelezi's Inkatha movement (primarily Zulu).

June 19—Parliament repeals Separate Amenities Act, paving way for integration of all public facilities, opening formerly whites-only public facilities.

June 20—Mandela begins 12-day, eight city US visit, including address to UN General Assembly.

June 25—Mandela meets with President Bush, calls on USA to maintain sanctions against the Pretoria government.

August 6—Mandela and De Klerk make breakthrough agreement clearing the way for full-scale negotiations on a new power-sharing constitution. The ANC announced that it will immediately suspend its 29-year armed struggle against white-minority rule. Beginning September 1, the Pretoria government will allow the phased release of the remaining political prisoners—estimates range from 1,300 to several thousand—and will grant amnesty to about 22,000 anti-government exiles. Crucial to that process are the definition of political offenses and the repeal of internal security laws that have been used to impose criminal penalties for political acts.

September 24—President Bush receives De Klerk on his first official visit to the USA.

February 1, 1991—De Klerk announces his intention to repeal the Population Registration Act, Group Areas Act, and Land Acts.

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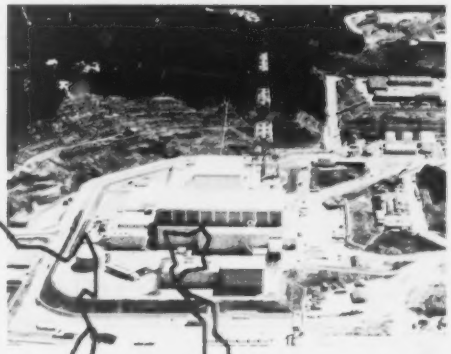
ASIA



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ASIA

CHINA

The return of political and economic stability and an examination of current and future energy requirements by the Chinese government highlighted the year for China National Nuclear Corporation (CNNC). China recognizes it cannot rely on development of fossil fuel for its growing energy demand. Power requirements are almost certain to intensify toward the end of the century and beyond, with a projected high annual GNP and population growth rate. Currently, electricity shortages incapacitate between 20 and 30 percent of China's industries. As a result, plans were released in June to accelerate China's nuclear power program.

Nuclear Power Units

Current goals call for nuclear generating capacity of 6,000 MWe by the year 2000 (with an additional 6,000 MWe under construction), and 30,000 MWe by 2015. Currently, three nuclear units are under construction, and two more have been approved. At the Qinshan site near Shanghai, phase one of a Chinese-designed, 300-MWe pressurized water reactor (PWR) facility go on-line in early 1992. The US$4 billion Daya Bay project in the Guangdong Province in southern China is expected to begin generating power in mid-1992. The Daya Bay station, which has twin 900-MWe PWRs, uses French nuclear technology and British conventional equipment. On the horizon are plans for two domestically-produced 600-MWe units at Qinshan, and two Soviet-manufactured 1000-MWe VVER reactors in northeastern China.

Nuclear Fuel Cycle

China has stepped up its uranium exploration efforts. After surveying one-third of the country's total land area, 200 new deposits were discovered, mostly in the southern regions of the country. CNNC also plans to set up its first intermediate-size plant for spent fuel reprocessing in Lanzhou. The facility, with a planned capacity of 100 kg per day, is expected to go into operation in 1998.

In 1990, for the first time, China has domestically-produced, commercial-grade fabricated reactor fuel. The fuel, intended for use at Qinshan, was produced in the Sichuan Province by its Yibin nuclear fuel fabrication plant.

Technology Sales

Internationally, China aided Pakistan in the construction of a teaching/research reactor, Pakistan Research Reactor 2 (PARR 2). PARR 2's nuclear system, designed by the Institute of Atomic Energy in Beijing, is an advanced, undermoderated reactor of tank-in-pool type, using a light water moderator, enriched uranium fuel, and metallic beryllium as a reflector. A commercial arrangement for China to provide Pakistan with a 300-MWe station is proceeding. A formal contract is expected to be concluded by mid-1991.

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INDIA

With the Nuclear Corporation's (NPC) announcement that Narora 1 is in commercial operation as of January 1, 1991, India has seven operating reactors—two boiling water reactors (BWR) and five pressurized heavy water reactors (PHWR)—plus seven more PHWRs under construction (**Table 14**). The country has an installed base of 1,374 MWe (about three percent of total electricity capacity) that is expected to rise to 1,814 MWe by 1993. Narora 2 is scheduled to be in commercial operation by late-1991, and Kakrapar 1, north of Bombay, is planned to go critical in late 1992, followed by Kakrapar 2 one year later. Site work has begun on four more 220-MWe PHWRs: Rajasthan 3 and 4 in the North, and Kaiga 1 and 2 on the Arabian Sea.

Table 14
NUCLEAR POWER UNITS IN INDIA

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh Net)
Kalpakkam 1 (MAPS)	NPC[2]	220	PHWR	1984	50	967
Kalpakkam 2 (MAPS)	NPC	220	PHWR	1985	57	1,089
Rajasthan 1 (RAPS)	NPC	207	PHWR	1973	23	421
Rajasthan 2 (RAPS)	NPC	207	PHWR	1981	63	1,142
Tarapur 1 (TAPS)	NPC	150	BWR	1969	82	1,071
Tarapur 2 (TAPS)	NPC	150	BWR	1969	65	849
Total		**1,144**		***(1990 Average:***	**55)[3]**	**5,539**

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	Percent Complete[4]
Kaiga 1	NPC	220	PHWR	1995	18
Kaiga 2	NPC	220	PHWR	1996	18
Kakrapar 1 (KAPP)	NPC	220	PHWR	1993	57
Kakrapar 2 (KAPP)	NPC	220	PHWR	1994	44
Narora 1 (NAPP)	NPC	220	PHWR	1991[5]	100
Narora 2 (NAPP)	NPC	220	PHWR	1991	100
Rajasthan 3	NPC	220	PHWR	1995	10
Rajasthan 4	NPC	220	PHWR	1996	10
Total		**1,760**			

[1] COD = Commercial Operation Date (actual or expected)
[2] NPC = Nuclear Power Corporation (Department of Atomic Energy)
[3] Average does not include those units which entered commercial operation or were retired during 1990.
[4] Source: *Nuclear News*
[5] Source: *NPC*. Contrary to other sources, NPC stated that Narora 1 will be declared in commercial operation on January 1, 1991. For this reason, the unit was removed from the 1989 "Units In Operation" listing.

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ASIA

NPC hopes to have a nuclear generating capacity of ten percent of total electricity requirements (10,000 MWe gross) by the end of the century, although budget cuts and reactor problems make this goal optimistic. Nevertheless, the country's nuclear generating capability is expected to grow rapidly in the next decade. India is relying on indigenous design, engineering, and construction of PHWRs and Fast Breeder Reactors (FBR) to increase its capacity and to minimize its dependency on outside suppliers.

Long-term nuclear power plans call for eleven new reactors: four 220-MWe PHWRs at Kaiga (two already under construction); two 220-MWe PHWR units at Rajasthan (under construction); two 470-MWe PWRs at Tarapur; two Soviet-designed 953-MWe units at Kudankulam; and a 500-MWe(gross) prototype FBR at Kalpakkam, near Madras. The NPC will rely on construction and operating experience from its experimental 15-MWe fast breeder test reactor for the latter, despite the fact that the test unit burns mixedcarbide fuel instead of the mixed-oxide type fuel planned for Kalpakkam.

India is negotiating with both France and the Soviet Union to supply two 1,000-MWe(gross)-class reactors, scheduled to begin operating by 1998 and 1999. Price, credit terms, and percentage of domestic components are a large part of the negotiations.

India has one uranium production facility, Jaduguda, that produces 550 thousand pounds equivalent U_3O_8 annually. It plans a second mill, 15 kilometers away at Turamidh, that should begin limited extraction in 1992. India is likely to phase out production at Jaduguda as Turamidh, with a planned yearly output of one million pounds, is phased in.

India's nuclear policy purposely avoids reliance on enriched uranium; consquently, its fuel cycle facilities focus on heavy water production. Government plans call for four new heavy water plants by 2000. The new plants will augment existing plants at:

- Manuguru in Andhra Pradesh state.
- Hazira, in Gujarat state.
- Baroda, Koda, Nangil, Talcher in eastern Orissa.
- Tahi in western Maharashtra state.
- Tuticorin in southern Tamil Nadu state.

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JAPAN

Tokyo Electric Power Company (TEPCO) started up Japan's 39th and 40th nuclear plants in 1990: Kashiwazaki Kariwa 2 and 5 (**Figure 7**). These reactors, each having a capacity of 1,045 MWe, began commercial operation in September and April, respectively. Japan continued to maintain very high capacity factors compared to world averages, and ended the year with an overall average of over 70 percent. The program now has a total net capacity of 30,310 MWe (**Table 15**) and provided 26.1 percent of the total electricity generated in Japan in 1990.

Significant progress was made toward completion of all twelve of Japan's nuclear plants under construction. Several projects doubled their construction progress since the end of 1989. The next reactors expected to come on line will be two PWRs: Hokkaido Electric Power Company's Tomari 2 and Kansai Electric Power Company's (Kansai EPC) Ohi 3. Together, the units will contribute almost 1,700 MWe once they are connected to the grid in 1991 (**Table 16**).

No new construction began on any of Japan's planned units during 1990. The only new developments concerning planned future units was the announcement that the estimated completion date of Electric Power Development Corporation's (EPDC) Ohma reactor has been postponed three years, until the year 2000. The postponement is due primarily to slow-moving discussions with local fishery associations over appropriate compensation for their loss of fishing rights. Ohma, a 570-MWe ATR, represents EPDC's first commercial venture into nuclear power and will be the largest advanced thermal reactor in Japan after Power Reactor and Nuclear Development Corporation's (PNC) 148-MWe plant in Fugen.

Economic Developments

The year 1990 was one of significant developments throughout Japan and especially within its nuclear industry. Overall, the Japanese economy began to show steady signs of slower growth. During the year, the Japanese stock market, the Nikkei, lost over 45 percent of its value, as economic implications of the Persian Gulf crisis reminded Japan of its complete dependence on foreign sources of energy.

The summer of 1990 was a particularly difficult time for the three largest utilities (TEPCO, Kansai EPC, and Chubu EPC) as they experienced large increases in electricity demands during widespread heatwaves that broke many 100-year record-high temperatures. Large-scale electricity conservation programs were quickly implemented to combat the unexpected demand. Given its large residential customer base, TEPCO was especially hard hit. And the situation was exacerbated by the fact that its Fukushima II-3 plant was not operating until November, and Fukushima I-5 was shutdown for 4 1/2 months from July until December for scheduled inspections. Kansai's Takahama 2 was also out of service: it was shutdown for regularly-scheduled inspection and maintenance from April through the end of the year.

In addition to summer's heatwave, political developments surrounding the Gulf Crisis in Kuwait meant huge price increases for oil. Although most of the Japanese utilities have shock absorbers in their supply contracts, these measures are effective only during short-lived price surges of up to three months. Expectedly, the nine regional utilities reported sharply lower earnings during their fiscal third quarter (November 1990-January 1991).

Table 15
JAPANESE ANNUAL ADDITIONS OF NUCLEAR GENERATING CAPACITY
1966-1990

Year	Capacity Addition (Gross MWe)	Total MWe at Year End
1966-1979	—	15,117
1980	0	15,117
1981	559	15,676
1982	1,666	17,342
1983	0	17,342
1984	2,514	19,856
1985	4,830	24,686
1986	0	24,686
1987	3,360	28,046
1988	0	28,046
1989	1,399	28,251
1990	2,200	31,645

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Public Opposition

Siting problems and public opposition to new projects became more widespread and vocal during 1990. The most significant national issues actually came to the forefront of the news in the first two months of 1991 with the Aomori prefectorial elections and an incident at Kansai's Mihama 2 reactor.

During the first two months of 1991, the future of Japan's Rokkasho-Mura fuel cycle facility was hanging precariously in the balance, as two anti-nuclear candidates entered the prefecture's gubernatorial race vowing to freeze or kill the project if elected. The incumbent, Mr. Kitamura, although faced with stiff competition, drew upon his pro-nuclear and pro-development constituency, the nuclear power industry, and the Liberal Democratic Party to emerge victorious in early February. Nuclear industry planners and utilities were very concerned over the possible postponement of Rokkasho-Mura, since the project was developed to give Japan capabilities in several areas and essentially complete its domestic fuel cycle. Without it, many future plans regarding enrichment, reprocessing, and high-level waste storage would have had to be reconsidered.

Japan's electric utilities identified the need to increase public awareness several years ago, and have been aggressively pursuing this goal through local and national programs. The election in Aomori provided even more reason for electric utilities to redouble their educational efforts to inform the public on nuclear power technology and related issues.

The other major news item entailed an operating incident at Mihama 2 on February 9, 1991, less than one week after Mr. Kitamura was reelected. A tube in the steam generator ruptured, and led to the automatic activation of the Emergency Core Cooling System. Though the incident was not severe, and would rate only a level 1 or 2 (out of 7) on the nuclear accident severity scale established by the International Atomic Energy Agency, it was the most serious incident ever at a Japanese reactor. Consequently, the event has been extensively covered by the media, and industry supporters fear that anti-nuclear opposition may use the emotional response of the public to slow or even stop portions of the country's nuclear growth plans.

With regard to future government policy toward nuclear power, the Ministry of International Trade and Industry (MITI) issued a study and a strong statement in June in favor of further development of nuclear energy as a part of Japan's comprehensive energy supply program. The plan includes bringing on-line all current projects under construction, plus approximately 30,000 MWe of new projects. Among the new projects are units currently planned to generate up to 13,000 MWe. Industry reaction to MITI's plan was rather pessimistic, since attaining the goals could be very difficult given the current level of public opposition, and the very limited number of possible sites available in the country. However, Japan continued to demonstrate its commitment to the long-term development of nuclear energy in 1990, because of its ability to reduce the country's dependence on foreign sources of energy, as well as its potential for limiting global warming.

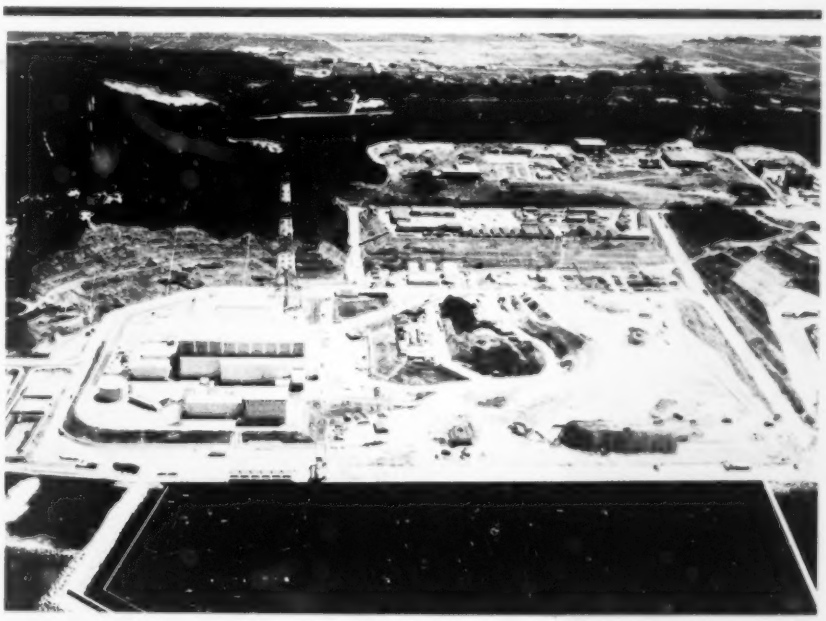

Figure 7 — Kashiwazaki-Kariwa 5, one of Japan's two new 1,045 MWe (net) units, began commercial operation in April 1990. *(Photo courtesy of Tokyo Electric Power Co.)*

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Table 16
NUCLEAR POWER UNITS IN JAPAN

Unit	Lead Utility or Fuel Buyer	Units In Operation: Capacity (MWe Net)	Type	COD [1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh Net)
Fugen	PNC[2]	148	ATR	1979	85	1,099
Fukushima I-1	Tokyo EPC[3]	439	BWR	1971	63	2,044
Fukushima I-2	Tokyo EPC	760	BWR	1974	47	3,158
Fukushima I-3	Tokyo EPC	760	BWR	1976	44	2,946
Fukushima I-4	Tokyo EPC	760	BWR	1978	64	4,265
Fukushima I-5	Tokyo EPC	760	BWR	1978	60	3,987
Fukushima I-6	Tokyo EPC	1,067	BWR	1979	83	7,719
Fukushima II-1	Tokyo EPC	1,067	BWR	1982	89	8,285
Fukushima II-2	Tokyo EPC	1,067	BWR	1984	67	6,260
Fukushima II-3	Tokyo EPC	1,067	BWR	1985	10	934
Fukushima II-4	Tokyo EPC	1,067	BWR	1987	76	7,082
Genkai 1	Kyushu EPC	529	PWR	1975	59	1,833
Genkai 2	Kyushu EPC	529	PWR	1981	100	4,650
Hamaoka 1	Chubu EPC	515	BWR	1976	46	2,074
Hamaoka 2	Chubu EPC	806	BWR	1978	83	5,825
Hamaoka 3	Chubu EPC	1,066	BWR	1987	71	6,663
Ikata 1	Shikoku EPC	538	PWR	1977	78	3,654
Ikata 2	Shikoku EPC	538	PWR	1982	100	4,708
Kashiwazaki-Kariwa 1	Tokyo EPC	1,067	BWR	1985	64	6,027
Kashiwazaki-Kariwa 2	Tokyo EPC	1,045	BWR	1990	—	2,378
Kashiwazaki-Kariwa 5	Tokyo EPC	1,045	BWR	1990	—	7,865
Mihama 1	Kansai EPC	320	PWR	1970	70	1,953
Mihama 2	Kansai EPC	470	PWR	1972	75	3,095
Mihama 3	Kansai EPC	780	PWR	1976	100	6,873
Ohi 1	Kansai EPC	1,120	PWR	1979	55	5,389
Ohi 2	Kansai EPC	1,120	PWR	1979	67	6,622
Onagawa 1	Tohoku EPC	497	BWR	1984	67	2,908
Sendai 1	Kyushu EPC	846	PWR	1984	82	6,093
Sendai 2	Kyushu EPC	846	PWR	1985	82	6,092
Shimane 1	Chugoku EPC	439	BWR	1974	98	3,788
Shimane 2	Chugoku EPC	791	BWR	1989	78	5,153
Takahama 1	Kansai EPC	780	PWR	1974	92	6,274
Takahama 2	Kansai EPC	780	PWR	1974	25	1,736
Takahama 3	Kansai EPC	830	PWR	1985	92	6,679
Takahama 4	Kansai EPC	830	PWR	1985	70	5,098
Tokai 1[4]	JAPC[5]	159	GCR	1966	64	897
Tokai 2	JAPC	1,056	BWR	1978	79	7,290
Tomari 1	Hokkaido EPC	550	PWR	1989	80	3,813
Tsuruga 1	JAPC	341	BWR	1970	66	1,978
Tsuruga 2	JAPC	1,115	PWR	1987	72	7,037
TOTAL		**30,310**		*(1990 Average:*	**70)**[6]	**182,224**

[1] COD = Commercial Operation Date
[2] PNC = Power Reactor and Nuclear Fuel Development Corporation
[3] EPC = Electric Power Company
[4] Will be decommissioned after 1995.
[5] JAPC = Japan Atomic Power Company
[6] Average does not include those units which entered commercial operation or were retired during 1990.

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Table 16
NUCLEAR POWER UNITS IN JAPAN
(continued)

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD [1]	Percent Complete [2]
Genkai 3	Kyushu EPC [3]	1,121	PWR	1994	55
Genkai 4	Kyushu EPC	1,121	PWR	1997	18
Hamaoka 4	Chubu EPC	1,045	BWR	1993	55
Ikata 3	Shikoku EPC	846	PWR	1995	46
Kashiwazaki-Kariwa 3	Tokyo EPC	1,045	BWR	1993	61
Kashiwazaki-Kariwa 4	Tokyo EPC	1,045	BWR	1994	41
Monju	PNC [4]	280	LMFBR	1993	91
Ohi 3	Kansai EPC	1,121	PWR	1991	92
Ohi 4	Kansai EPC	1,121	PWR	1993	41
Onagawa 2	Tohoku EPC	784	BWR	1995	13
Shika 1	Hokuriku EPC	513	BWR	1993	58
Tomari 2	Hokkaido EPC	550	PWR	1991	98
TOTAL		**10,592**			

Units Planned

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD [1]
Ashihama 1 [5]	Chubu EPC	1,045	BWR	1997
Ashihama 2 [5]	Chubu EPC	1,045	BWR	1998
Higashi Dori 1 [5]	Tohoku EPC	1,045	BWR	1999
Hohoku 1 [5]	Chugoku EPC	1,045	BWR	1997
Hohoku 2 [5]	Chugoku EPC	1,045	BWR	1999
Kashiwazaki-Kariwa 6	Tokyo EPC	1,311	BWR	1996
Kashiwazaki-Kariwa 7	Tokyo EPC	1,356	BWR	1997
Kashiwazaki-Kariwa 8	Tokyo EPC	1,356	BWR	Unspecified
Maki 1	Tohoku EPC	796	BWR	2000
Namie-Odaka [5]	Tohoku EPC	796	BWR	2003
N1 [5]	Hokuriku EPC	1,100	PWR	2003
Ohma [5]	EPDC [6]	556	ATR	2000
Oura 1 [5]	Kansai EPC	1,200	PWR	1996
TOTAL		**13,696**		

[1] COD = Commercial Operation Date (expected)
[2] Source: *Atoms In Japan*
[3] EPC = Electric Power Company
[4] PNC = Power Reactor and Nuclear Fuel Development Corporation
[5] No authorization for development planning.
[6] EPDC = Electric Power Development Company

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Figure 8
JAPAN
NUCLEAR POWER UNITS AND FUEL CYCLE FACILITIES

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ASIA

SOUTH KOREA

South Korea continued its aggressive pursuit of nuclear power in 1990, as Korea Electric Power Corporation (KEPCO) ordered its second heavy water reactor (Wolsong 2) from Atomic Energy of Canada, Limited. In addition, two PWR units (Yonggwang 3 and 4) were under construction, and two more PWR units (Uljin 3 and 4) were in the advanced stages of planning (**Table 17 & Figure 9**).

An integral part of Korea's nuclear program is the increasing reliance on South Korean industry to design, supply parts, and construct its own nuclear units. Construction on the 700-MWe Wolsong 2 unit is expected to start in 1992 with startup of the unit slated for 1997. Of its estimated cost of US$1 billion, about 60 percent will be spent locally.

Table 17
NUCLEAR POWER UNITS IN SOUTH KOREA

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh net)
Kori 1	KEPCO[2]	556	PWR	1978	70	3,409
Kori 2	KEPCO	605	PWR	1983	82	4,353
Kori 3	KEPCO	895	PWR	1985	86	6,738
Kori 4	KEPCO	895	PWR	1986	78	6,131
Uljin 1	KEPCO	920	PWR	1988	76	6,157
Uljin 2	KEPCO	943	PWR	1989	67	5,516
Wolsong 1	KEPCO	629	HWR	1983	86	4,728
Yonggwang 1	KEPCO	900	PWR	1986	86	6,790
Yonggwang 2	KEPCO	900	PWR	1987	75	5,880
Total		**7,243**		*(1990 Average:*	**78)[3]**	**49,702**

Units Planned

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	Percent Complete
Yonggwang 3	KEPCO	900	PWR	1995	33
Yonggwang 4	KEPCO	900	PWR	1996	33
Wolsong 2	KEPCO	629	HWR	1998	planned
Uljin 3	KEPCO	943	PWR	1998	planned
Uljin 4	KEPCO	943	PWR	1999	planned
Total		**4,315**			

[1] COD = Commercial Operation Date (actual or expected)
[2] KEPCO = Korea Electric Power Corporation
[3] Average does not include those units which entered commercial operation or were retired during 1990.

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KEPCO currently operates nine nuclear units with 7,266 MWe of capacity. When finished, the five nuclear units in the construction/planning phase would bring KEPCO's operating capacity to 11,738 MWe. During 1990, 49.5 percent of South Korea's electricity was generated by nuclear power.

Nuclear Fuel Supply

The most important event in KEPCO's 1990 nuclear fuel supply activities was the signing of a ten-year enriched uranium product contract with Techsnabexport (TENEX) of the Soviet Union. Under this contract, deliveries for 1990 totalled 40 metric tons of enriched uranium.

With the addition of TENEX as a major fuel supplier, KEPCO has diversified to three suppliers of uranium enrichment services, consisting of TENEX, DOE, and Eurodif.

On the natural uranium side, there were no new supply contracts signed by KEPCO, but contracted deliveries were made during the year from their Australian, Canadian, and French suppliers. In addition to purchases under long-term contracts, KEPCO's uranium supply strategy includes equity participation in the Cigar Lake and Dawn Lake projects in Canada, as well as the Crow Butte project in the United States.

Fuel Cycle Facilities

In March 1990, the Korea Nuclear Fuel Company (KNFC) began full operation at its PWR fuel fabrication plant at Taejon (**Figure 10**). A year earlier, KNFC, a KEPCO subsidiary, had begun to produce fuel assemblies from UO_2 supplied by Siemens subsidiary SBH (Siemens Brennelementewerk Hanau GmbH). The March 1990 date marked the opening of KNFC's reconversion line, whereby it could produce its own UO_2 powder.

KNFC has been very active in developing its own fuel assembly design, including a higher-burnup design. South Korea is also self-sufficient in the design and production of heavy water reactor fuel bundles.

Figure 9
SOUTH KOREA
NUCLEAR UNITS AND FUEL CYCLE FACILITIES

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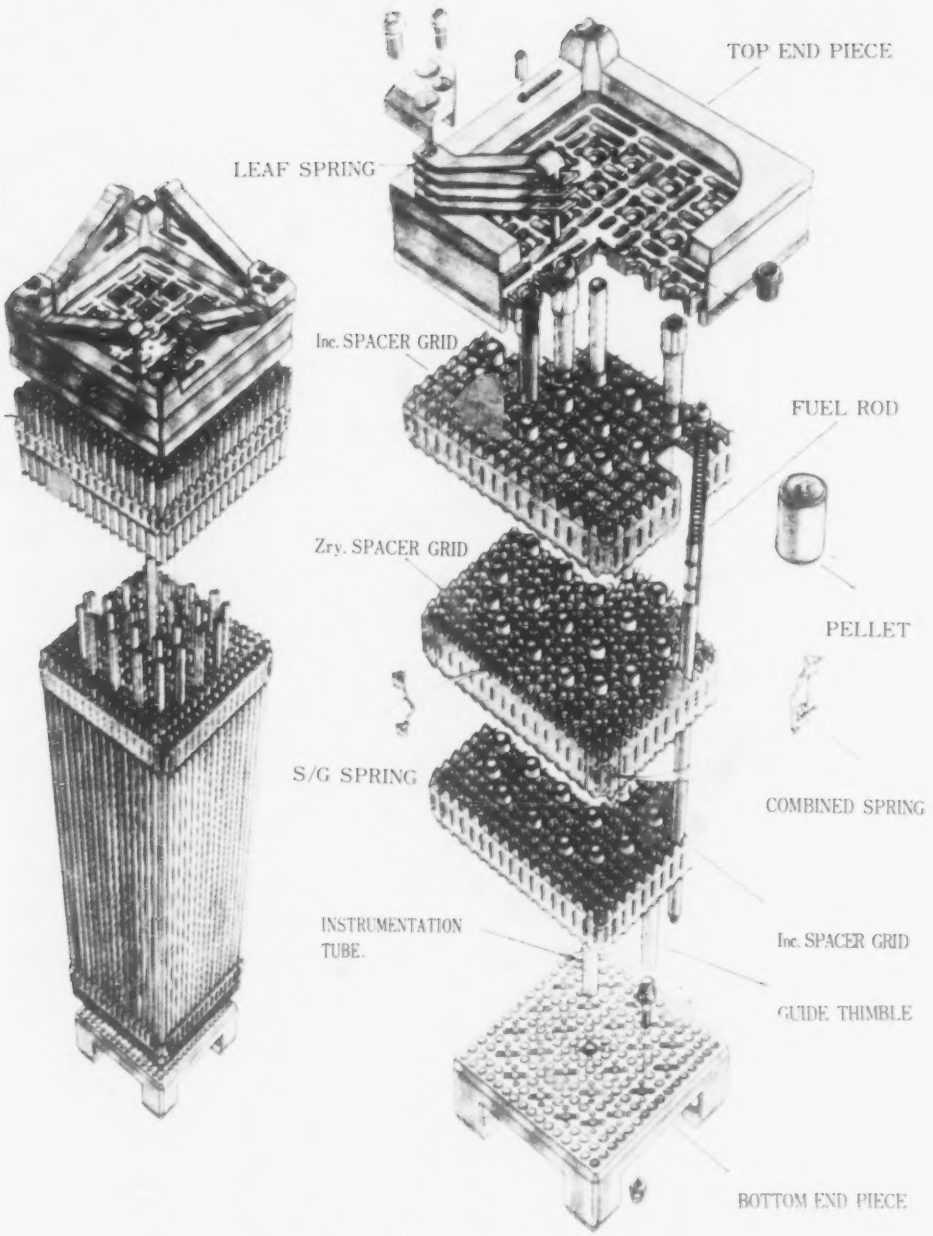

Figure 10 — 17 x 17-type Korea Fuel Assembly

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TAIWAN

Taiwan's electricity is supplied by the government-owned Taiwan Power Company (Taipower), headquartered in Taipei. Taipower has six operating nuclear power reactors, no units under construction, and one additional two-unit station planned. The utility's six nuclear units each operated at higher capacity factors in 1990 than in 1989. The seventh and eighth units had been deferred since 1985, but the government recently granted Taipower permission to once again begin planning and construction of its fourth station that will contain two 1,000-MWe PWRs.

Nuclear Power Program

Taipower's six operating reactors have a combined net capacity of 4,884 MWe (**Table 18**), and achieved an average capacity factor in 1990 of 73 percent, up from 63 percent in 1989. Taipower's reactors are located on three, two-unit nuclear sites (**Figure 11**). Two stations, Chinshan and Kuosheng, contain GE-supplied boiling water reactors; the other station at Maanshan has two 890-MWe, Westinghouse-supplied pressurized water reactors.

Taipower is the sole electric utility in Taiwan and is responsible for developing, generating, supplying, and marketing electricity on the island and its offshore islets. At the end of 1990, nuclear power constituted about 30.5 percent of Taipower's installed generating capacity, supplying about 38.3 percent of Taipower's electricity for the year. In 1987, nuclear power supplied a record 52 percent of Taiwan's total electricity generation.

Taipower's nuclear power construction program has been beset by uncertainty and indecision since 1985, when the Ministry of Economic Affairs suspended plans for Taiwan's seventh and eighth nuclear units, planned for the Yenliao site. Taipower already had solicited international bids for the reactors and turbine generators, with the aim of completing the units by 1988 and 1989, respectively. The plans were suspended by the government because of less-than-expected growth in power demand.

In the interim, Taipower has expended a great deal of effort in addressing public concerns about nuclear power. In 1988, the Atomic Energy Council of Taiwan invited an international panel of nuclear safety experts to review nuclear safety practices at Taipower's plants. The panel praised Taipower's nuclear program and its safety record, and also indicated areas where performance could be improved.

Table 18
NUCLEAR POWER UNITS IN TAIWAN

		Units In Operation				
Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh net)
Chinshan 1	Taipower[2]	604	BWR	1978	56	2,980
Chinshan 2	Taipower	604	BWR	1979	65	3,457
Kuosheng 1	Taipower	948	BWR	1981	82	6,826
Kuosheng 2	Taipower	948	BWR	1983	71	5,945
Maanshan 1	Taipower	890	PWR	1984	77	5,971
Maanshan 2	Taipower	890	PWR	1985	77	6,004
TOTAL		**4,884**		***(1990 Average:***	**73)[3]**	**31,183**

[1] COD = Commercial Operation Date
[2] Taipower = Taiwan Power Corporation
[3] Average does not include those units which entered commercial operation or were retired during 1989.

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By late-1990, the ruling party of the government had a more favorable attitude toward nuclear power, but other political parties were still opposed. But, as a result of the Persian Gulf crisis, Taiwan has become more aware of its energy dependence vulnerability: it had relied on Kuwait for 17 percent of its oil. In August, Premier Hau Pei-Tsun and several other high-level officials began focusing on the possibility of developing more nuclear power to replace oil as Taiwan's main source of energy. Economics Minister Vincent Siew later announced that the Premier had asked him to accelerate efforts to reduce public fears about nuclear power.

Nuclear Fuel Activities

Taipower was not active in the uranium or enrichment markets during 1990, relying on its existing long-term contracts and significant inventory to meet its uranium needs during the year. Its current long-term contracts cover more than half of its needs on an annual basis. Taipower has a goal of obtaining 70 percent of its uranium supplies from the long-term and spot markets, and 30 percent from joint ventures in uranium projects, at this time primarily in the USA.

In 1990, Taipower's joint-venture partner in the USA was UPR (formerly Union Pacific Resources). Under this arrangement, Taipower has a one-third ownership of a reserve estimated at 4 million pounds equivalent U_3O_8 located in the Arizona Strip area near the Grand Canyon. Although there has been no production yet from any such joint-venture projects, the partnership has made significant discoveries in the strip.

In December 1990, in an expansion of its partnership, Taipower's board approved an investment in UPR's Reno Creek in-situ leaching project in Wyoming. If government approvals are received, Taipower will purchase a one-third interest in the project's reserves estimated at five million pounds equivalent U_3O_8. The Reno Creek project is currently deferred, although exploration efforts in the area continue.

All of Taipower's nuclear fuel needs are met from overseas sources. Taipower purchases its enrichment services from the US DOE and Cogema of France. In 1990, the utility procured fabrication from three different fabricators for its three different stations, and the contracts covered several reloads with options for additional reloads. Taiwan plans to develop domestic fuel fabrication capability when its nuclear power program expands sufficiently.

Figure 11
TAIWAN
NUCLEAR POWER UNITS

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OTHER COUNTRIES

PAKISTAN

Pakistan's only nuclear power plant, Kanupp (137-MWe pressurized heavy water reactor) did not operate very well during 1990, with a capacity factor of only 32 percent. Throughout its history, the unit has been shut down frequently for long periods of maintenance, repair, or modification. Nevertheless, Pakistan is still pursuing its nuclear program. The Prime Minister has approved plans for six additional nuclear units with a total capacity of 2,400 MWe (gross), although Pakistan's ability to finance these plants may be problematic. China has agreed to supply a 300-MWe pressurized water reactor (PWR) and the French, a 900-MWe PWR. The countries have agreed that the plants would be subject to international safeguards.

In support of its nuclear plans, Pakistan has a fuel fabrication facility at Kundian, and the Kahuta centrifuge enrichment plant near Islamabad. Pakistan also operates the Baghalchar uranium mine in the Dera Ghazi Khan District. The mine was reopened in March 1990, after being closed for over four months due to localized ethnic violence.

PHILIPPINES

The Philippines' only nuclear power plant, PNPP 1, a 620-MWe PWR, has never operated, despite persistent power shortages. The nearly-completed plant has remained closed because of the present government's allegations of bribery to former government officials, and poor workmanship during construction. In 1988, the Philippine government filed a lawsuit against Westinghouse and Burns & Roe, the nuclear vendor and architect/engineer for the plant. To date, the suit has not been resolved.

INDONESIA

A 1987 study concluded that nuclear power would be a viable alternative for Indonesia in the long-term, and by the end of the century, nuclear could replace part of the country's coal- and oil-generated power. In August 1989, President Suharto agreed to the construction of Indonesia's first nuclear power plant. The proposed 600-MWe station will be built on the north-central coast of the main island of Java. The country will consider either a boiling water reactor (BWR) or pressurized water reactor (PWR), and plans to have the plant operating by 2003. Indonesia also plans to build six 600-MWe PWRs and six BWRs by the year 2015. Indonesia has identified uranium deposits of about 25 million pounds equivalent U_3O_8 in the Kalan area of West Kalimantan (Borneo), north of Java.

THAILAND

Thailand first considered nuclear power in the late 1960s, but conventional fuels were more economical. However, Thailand's burgeoning economy has now caused the national electric reserve to fall from 35 percent in 1987, to only 3 percent in 1989. Consequently, the government supports a proposal by the Electricity Generating Authority of Thailand (EGAT) to build a nuclear plant in Thailand by the end of the century. EGAT technicians have estimated the cost to develop the 900-MWe reactor at US$1.6 billion.

The Royal Thailand Department of Mineral Resources began a preliminary uranium exploration program in the 1960s. Starting in 1984, the country conducted airborne radiometric and magnetic studies of the entire country, and initiated a multi-element geochemical program, in order to further identify uranium-rich provinces.

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AUSTRALIA

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AUSTRALIA

URANIUM PRODUCTION

Australia's 1990 uranium output was nearly 9.2 million pounds U_3O_8, down slightly from the 9.5 million pounds produced in 1989. Reduced output from Energy Resources of Australia's (ERA) Ranger mine in the Northern Territory resulted in the decrease that was only partially offset by increased production from South Australia's Olympic Dam project.

ERA

ERA's 1990 production of 6.4 million pounds U_3O_8 was 11 percent below the 7.2 million pounds produced in 1989. This decrease reflects the reduction of the mill head grade to the average grade of the remaining reserves, and the termination of future annual deliveries amounting to 1.25 million pounds U_3O_8 to Germany's RWE AG, ERA's largest shareholder/customer.

Olympic Dam

While production from Olympic Dam increased from 2.2 million pounds in 1989 to nearly 2.8 million pounds U_3O_8 in 1990, it remained well below nominal capacity of 4.2 million pounds annually. Olympic Dam, a Western Mining Company-BP Australia joint venture, concluded one new long-term contract during the year; but since the contract did not require any near-term deliveries, and since uranium prices continue to be weak, the project's production plans focused on copper-rich ore at the expense of uranium. Following the failure of its proposed deal with UK-based RTZ, British Petroleum (BP) is continuing to seek a buyer for its 49 percent interest in Olympic Dam.

Queensland Mines

With mining and milling activities at its Nabarlek site concluded some years ago, Queensland Mines Limited (QML) concentrated on marketing and site cleanup activities during 1990. Early in the year, QML received government approval of its first long-term contracts with US utilities. Subsequently, in a complex transaction, the German trading company, Nukem, took assignment of all QML's long-term supply contracts and purchased QML's total uranium inventory of over 6 million pounds U_3O_8. At year end, QML was negotiating with an unidentified market participant to form a joint venture to include the Nabarlek mill and surrounding exploration leases.

OTHER DEVELOPMENTS

The March 1990 election returning Prime Minister Hawke's Labor Government to power delayed, until the July 1991 party conference, any action by the government's Uranium Policy Review Committee with respect to possible changes in Australia's uranium policy. These changes are expected to focus on (and probably liberalize or remove) the three-mine policy (really a "two-mine" policy with the cessation of operations at Nabarlek). Despite current market conditions, a number of potential Australian producers are convinced that, given the amount of unfilled demand in the world's long-term market, there remains an opportunity for significant expansion of Australia's supplier role. Among the potential producers are Pancontinental and CRA, Ltd. with their Jabiluka and Kintyre deposits, respectively.

In mid-year General Atomics, the owner of the US-based convertor Sequoyah Fuels, purchased the Beverley uranium property in South Australia. The deposit is estimated to contain about 30 million pounds U_3O_8 at an average grade of 0.27 percent, and will be mined with in-situ techniques.

Finally, near the end of the year, it seemed apparent that three of ERA's principal shareholders, North Broken Hill Pty., Ltd., Cogema, and Rheinbraun AG, having acquired a third of Pancontinental's common shares, had developed serious designs on the Jabiluka deposit. While discussions between the parties are on-going, it is clear that any transaction involving either acquisition of the Jabiluka deposit, or sharing of the Ranger mill, will be complex both commercially and politically.

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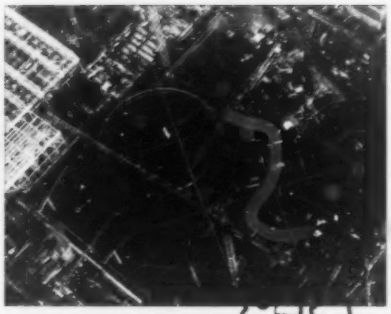

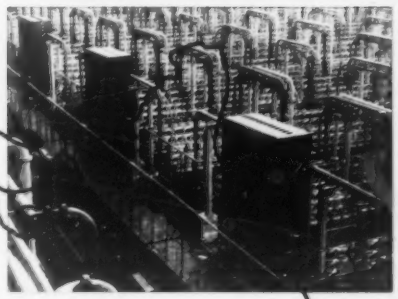

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EUROPE OVERVIEW

The process of the integration of eastern and western Europe after forty years of division, begun in earnest during 1989, accelerated during 1990, with dramatic consequences for the worldwide nuclear power industry. In particular, disclosures of the vast scale of historical uranium production in eastern Europe shocked many analysts and led to a drastic reevaluation of the worldwide supply and demand of uranium. It now appears that Europe, including the Soviet Union west of the Ural Mountains, may have produced more uranium historically than any other continent including North America. On the other hand, nuclear power development in eastern Europe has lagged far behind that of western Europe and North America. During 1990 it became clear that the integration of the continent will involve increasing the exchanges of eastern Europe's commodities for western Europe's financing, technology, and methods.

Integration also accelerated within western Europe among the twelve member countries of the European Community (EC) and the five members of the European Free Trade Association (EFTA). During 1990 Sweden, the largest EFTA country, declared its desire to join the EC, as did Austria, signaling the further expansion of the EC in coming years. In line with the EC's goal of a free internal market, two major initiatives were undertaken to liberalize the electricity industry: First, in October 1990, a law requiring regional utilities to wheel power between neighboring utilitites, and second, in March 1991, a measure designed to break up power monopolies and allow free competition in electricity markets throughout the EC.

With the promise in Europe of economic liberalization, substantial economic improvement can be expected in the coming years. The prospects for a new generation of nuclear power stations should increase as the decade progresses. In the near future, however, natural gas will be the preferred fuel for new power stations across Europe, except in France.

Nuclear power generation in western Europe increased modestly during 1990 (**Table 19**), with significant capacity additions in France somewhat offset by shutdowns in France, Germany, Spain, and the UK. Nuclear power programs across eastern Europe were given critical attention during the year, resulting in several plant shutdowns and cancellations in eastern Germany, the Soviet Union, and other countries. Such critical attention in eastern Europe reflects the increased integration of Western industrial methods and safety standards.

As political changes have occurred, many barriers between the East and West have dissolved. One result is closer ties between the major industrial concerns involved in nuclear energy and uranium production. Consequently, unity of the industry across the continent appears achievable in the long term.

Table 19
1990 NUCLEAR POWER GENERATION IN WESTERN EUROPE

Country	Number of Units (end of 1990)	1989 Nuclear Generation (GWh gross)[1]	1990 Nuclear Generation (GWh gross)[1]	1990 Relative To 1989
Belgium	7	41,162	42,722	+ 3.8%
Finland	4	18,798	18,948	+ 0.8%
France	56[2]	301,722	314,103	+ 4.1%
Germany	21[3]	149,053	147,194	- 1.3%
Hungary	4	13,840	13,644	- 1.4%
Netherlands	2	4,019	3,440	- 14.4%
Spain	9[4]	56,118	54,264	- 3.3%
Sweden	12	65,600	68,183	+ 3.9%
Switzerland	5	22,754	23,598	+ 3.7%
United Kingdom	37[5]	71,276	68,755	- 3.5%
Yugoslavia	1	4,147	4,622	+ 11.5%
Total	**158**	**748,489**	**759,453**	**+ 1.5%**

[1] Source: *Nucleonics Week*
[2] Includes Superphénix, shut down for much of 1990. Excludes Saint Laurent A1 and Chinon A3, decommissioned during 1990.
[3] Excludes units in the former GDR. Excludes THTR-300 and Kalkar. Includes Mulheim-Kärlich, shut down since 1988, and Obrilheim, shut down for much of 1990.
[4] Excludes Vandellos 1, decommissioned at the end of 1990.
[5] Excludes Hunterston A1 and A2, and Winfrith, decommissioned in 1990.

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AUSTRIA

Gemeinschaftskraftwerk Tullnerfeld GmbH (GKT), owner of the cancelled Tullnerfeld boiling water reactor project, completed the sale of all its remaining nuclear fuel assets in 1990. Fabricated fuel from the plant was converted back to enriched UF_6 by Comurhex in France during the course of the year. Some of the unused nuclear equipment and components from the Tullnerfeld plant have been sold for use in other nuclear projects in Europe.

GKT continued examining plans to convert the plant to a gas-fired station. A formal application for such conversion will be submitted to the Austrian authorities in 1991. If the application is approved, licensing and construction is expected to require about five years; thus, the gas-fired plant could begin operating as early as 1996. Plant output is expected to range between 700 and 900 MWe. The final design and execution of the conversion of the plant likely will be undertaken by the GKT staff.

BELGIUM

Belgium's three largest utilities, UNERG, INTERCOM, and EBES, merged in 1990 to form a single electric utility named Electrabel. The merger will improve Belgium's competitive position in the European Community and will discourage potential takeover attempts by larger utilities. Electrabel is now the country's second-largest company, and is responsible for operating the nation's seven nuclear reactors. Together, these reactors supply approximately 65 percent of Belgium's demand for electricity, operating at an average capacity factor of 84 percent during 1990 (**Table 20**).

Electrabel owns approximately 20 percent of the two 1,455 MWe pressurized water reactors under construction at Chooz, France, near the French-Belgian border. Plans for

Table 20
NUCLEAR POWER UNITS IN BELGIUM

		Units In Operation				
Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1990 Net Capacity Factor (percent)	1990 Electricity Generation (GWh net)
Doel 1	Synatom	400	PWR	1975	82	2,859
Doel 2	Synatom	400	PWR	1975	57	1,988
Doel 3	Synatom	900	PWR	1982	87	6,867
Doel 4	Synatom	1010	PWR	1985	86	7,591
Tihange 1	Synatom	870	PWR	1975	88	6,713
Tihange 2	Synatom	901	PWR	1983	87	6,862
Tihange 3	Synatom	1020	PWR	1985	87	7,792
TOTAL		**5,501**		*(1990 Average:*	**84)**	**40,672**

[1] COD = Commercial Operation Date

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expansion of domestic nuclear generating capacity have been deferred indefinitely. However, Tractebel, the electrical engineering holding company of Electrabel, has announced it will cooperate with Electricité de France in development of France's REP-2000 advanced reactor program.

Synatom, Belgium's nuclear fuel supply company, continued to revise its long-term supply portfolio during 1990, as many of its contracts from the previous decade expired or came up for renegotiation. The company encourages supply diversity, having contracts with suppliers in all of the major uranium-producing regions of the world. Synatom is a shareholder in Eurodif and covers a significant share of its enrichment requirements from Eurodif. The Belgians have substantial reprocessing contracts with Cogema.

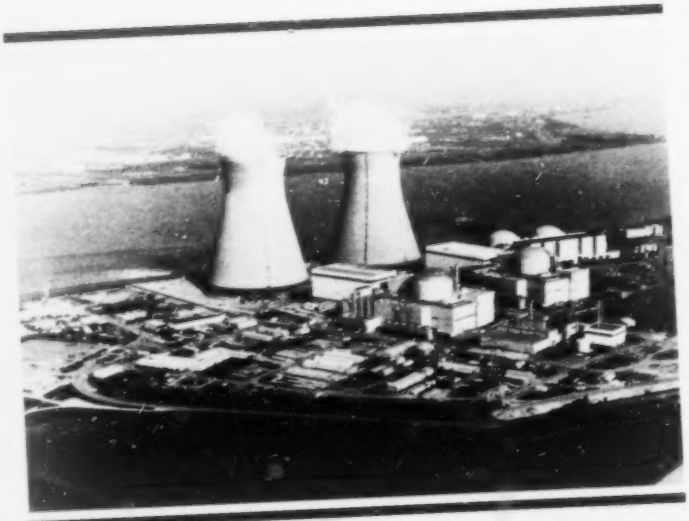

Figure 12 — The Doel nuclear power station, with four pressurized water reactors (2 x 400 MWe, 1 x 900 MWe, and 1 x 1010 MWe). *(Photo courtesy of Synatom.)*

BULGARIA

Bulgaria operated five Soviet-designed reactors during 1990: four 408-MWe vodo-vodyanoi energeticheskiy reaktors (VVER) and one 887-MWe VVER at the Kozloduy station. An additional VVER-1000 is under construction, and is expected to begin operation in 1993 after completion of retrofitting to meet Western safety standards.

Romania has complained to Bulgaria about radiation and pollution from the Kozloduy nuclear facility. During 1990 Romania and Bulgaria signed a protocol agreement to have an international group of experts conduct an environmental survey of the Kozloduy region, on both the Bulgarian and Romanian sides of the Danube River. Two VVER-1000 reactors under construction at the Belene site have been suspended due to local opposition, and the Bulgarian Parliament has commissioned a study to evaluate the plant's safety.

Bulgaria has estimated uranium resources including 39 million pounds equivalent U_3O_8 proven reserves, and 78 million pounds of additional reserves. Early production was derived from underground mines in the Balkan Mountains. Extensive exploration in other parts of the country revealed additional uranium environments, including sandstones. Bulgaria has launched a major program of solution mining that now accounts for 70 percent of its annual uranium production. Through 1990, the country's cumulative production totalled about 93 million pounds U_3O_8. Bulgaria relies on the Soviet Union for all fuel cycle services.

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CZECHOSLOVAKIA

In 1990, nuclear power provided over 30 percent of Czechoslovakia's electricity needs. The country is seeking to cut coal and lignite consumption nine percent by 1995, by increasing nuclear capacity to offset the shutting down of at least two coal-fired plants.

Czechoslovakia has eight Soviet-designed VVERs in operation, for a total capacity of 3,246 MWe. Six additional vodo-vodyanoi energeticheskiy reaktors (VVER) are under construction (3,396 MWe), and up to twelve more units are planned (approximately 10,000MWe). However, Austria has formally complained about the Bohunice Units 1 and 2 located on the Danube River, which forms the border between the two countries. Austria has even offered to supply up to 300 MWe of free power to Czechoslovakia for a year if those two reactors are shut down. The countries have agreed that if the final reports of the International Atomic Energy Agency inspection teams recommend closure of Bohunice 1 and 2, the Czechoslovakian government will follow such a recommendation. The two inspections were made in October 1990 and the final reports are expected in spring 1991.

Siemens AG was selected during 1990 to supply fully-automated control systems for Mochovce 1 and 2 to bring them up to Western safety standards. Siemens is also being considered to supply the same systems for six more reactors at the Dukovany and Temelin sites. The Czechoslovakian government is exerting considerable effort to ensure that Czech reactors meet Western safety standards.

Czechoslovakia held free elections in June 1990, and Vaclav Havel was elected President. One of his first challenges was the emergence of long-hidden nationalism among the country's two principal ethnic groups. In a move to address Slovak demands for independence, the government has officially renamed the country the "Czech and Slovak Federal Republic (CSFR)".

During 1990, the United States and CSFR reached a preliminary agreement for nuclear cooperation that will be submitted to the US Congress early in 1991. France and CSFR also have entered into an agreement for direct cooperation in nuclear energy, including nuclear safety, the back-end of the fuel-cycle, advanced reactors, public information, and training. In addition, the newly-formed Czechoslovak Nuclear Forum has accepted an invitation to become an associate member of Foratom. On the industrial side, the Czechslovakian manufacturer Skoda has expressed its intent to enter into a long-term business and technology agreement for its power systems operations with Westinghouse Electric Corporation.

Uranium Production

The CSFR has performed large-scale mining and milling of uranium since the end of World War II with the entire uranium output having been exported to the Soviet Union. Early in 1990, the government announced that it would stop uranium production by the end of the century, primarily because the Soviet Union has declined to renew its uranium purchase agreement with the CSFR. Under that agreement, the Soviet Union would accept uranium as partial payment for its enrichment services and fuel fabrication.

A new agreement was reached with the Soviet Union to allow the CSFR to market its uranium output internationally. Subsequently, the CSFR entered into an exclusive uranium marketing arrangement with the German intermediary, Ineruran GmbH in January 1990. The CSFR exported 13 percent of its 1990 production to the West and hopes to export about 45 percent of its 1991 production to the West. Production is believed to have totalled more than 4 million pounds U_3O_8 in 1990.

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FINLAND

Finland's four nuclear units achieved an average capacity factor of 89 percent in 1990 (**Table 21**), the second year in a row in which they achieved this high availability. Perusvoima Oy (PVO), a consortium of the two Finnish utilities, Imatran Voima Oy (IVO) and Teollisuuden Voima Oy (TVO), continued development of plans for a fifth nuclear unit. PVO has announced its intention to formally submit an application for the new project to Finnish authorities in the spring of 1991. If approval is received, requests for bids for a 1,100-MWe pressurized water reactor or boiling water reactor nuclear plant will be issued by summer 1991. PVO hopes to select the supplier by the end of the year so that construction can proceed and the plant can be operational in 1998.

In the interim, to meet Finland's growing demand for electric power, IVO is building a coal-fired plant planned to begin operation by late 1993. TVO is a minority participant in the project.

The Soviet Union remains the source of IVO's fabricated fuel and contained uranium for its Loviisa nuclear units, as well as the repository for IVO's spent fuel. TVO purchases the majority of its natural uranium needs under long-term supply contracts. TVO's enrichment needs are covered primarily by the Soviet Union.

Work on TVO's underground storage facility for low and medium level wastes continues on schedule. The facility is planned for operation in 1992. IVO continues to have success in its waste volume reduction program, so construction of additional storage facilities for low and medium level nuclear wastes could be further postponed.

Table 21
NUCLEAR POWER UNITS IN FINLAND

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh net)
Loviisa 1	IVO[2]	445	PWR	1977	85	3,308
Loviisa 2	IVO	445	PWR	1981	85	3,295
Olkiluoto 1	TVO[3]	710	BWR	1979	94	5,873
Olkiluoto 2	TVO	710	BWR	1982	93	5,766
TOTAL		**2,310**		*(1990 Average:*	**90)**	**18,242**

[1] COD = Commercial Operation Date
[2] IVO = Imatran Voima Oy
[3] TVO = Teollisuuden Voima Oy

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FRANCE

Electricité de France (EdF) brought two new 1,310-MWe pressurized water reactors (PWR) and a 1,300 MWe PWR into service during 1990 and retired two gas-cooled reactors (GCR). The new units were Penly 1, connected in May 1990; Golfech 1, in June 1990 (**Figure 13**); and Cattenom 3, in July 1990. Net nuclear generating capacity at year-end amounted to 55,758 MWe from 55 units (**Table 23**), not counting the Superphénix fast breeder reactor, which is owned by a European consortium and was shut down indefinitely in mid-1990. As in 1989, nuclear power accounted for 75 to 80 percent of French electricity generation in 1990. Capacity utilization was also unchanged at around 64 percent, with several outages for steam generator repair.

EdF is now building six PWRs: three in the 1,300-MWe class, and three in the larger 1,400-MWe class. The utility formally ordered the last of those units, Civaux 1, during 1990; it was the only nuclear power unit ordered in western Europe during the year. Of the units under construction, Cattenom 4 should be connected to the grid in 1991, and Penly 2 in 1992, bringing those stations to full capacity.

Following the closure of the Saint Laurent A1 and Chinon A3 GCRs in 1990, only two GCRs remain operating in the French system, and they will be decommissioned by 1995. In addition, the 305-MWe Chooz A PWR near the Belgian border, owned by a French/Belgian consortium, will be retired during 1991. The fate of the costly Superphénix project is in doubt after a series of technical problems and political opposition, particularly from the neighboring region of Geneva, Switzerland.

Framatome, EdF's reactor supplier, reverted to a state-controlled company in October 1990 following agreement of the shareholders to a stock redistribution. Compagnie Générale d'Electricité (CGE), a private company, had earlier acquired control of the vendor and threatened to change the company's management, but the government intervened to force a settlement. CGE agreed to reduce its position from 52 percent to 44 percent, with Credit Lyonnais, the state-owned bank, taking five percent and the other three percent purchased by the existing shareholders, including EdF and Commissariat a l'Énergie Atomique.

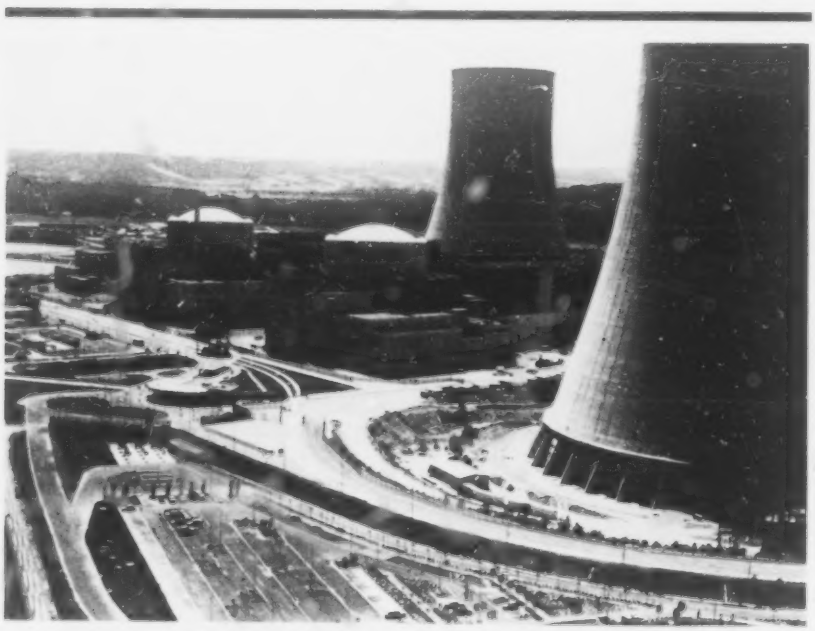

Figure 13 — The Golfech nuclear station: Golfech 1 is one of three reactors that France brought into service in 1990. It is in pre-commercial testing, and is planned for commercial operation in early 1991. (*Photo courtesy of EdF.*)

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EdF Results

EdF posted a profit of 100 million French francs (FF) in 1990 after recording a loss of FF 4.2 billion the previous year. The turnaround was attributed partly to staff reductions, streamlining of operations, and other cost-cutting measures said to have saved one billion francs. The utility is burdened by heavy debt from its nuclear plant construction program, but reduced overall indebtedness during the year from FF 232.5 billion to FF 226.1 billion.

Revenue increased by 6.4 percent to FF 156.5 billion during 1990. Of this amount, FF 11 billion came from power exports to neighboring countries. EdF sold a net 46,000 GWh abroad, with the principal buyers being utilities in Switzerland, Italy, and the UK (**Table 22**). EdF hopes to increase exports, and was helped by an European Economic Community measure adopted in October 1990 obliging grid operators to transport electricity between foreign entities. The German utility Badenwerk entered into a long-term contract with EdF during 1990, as did the Spanish utility Redesa. Under the Spanish contract, Redesa will purchase some 1000 MWe per year over a ten-year period.

EdF also made new initiatives in eastern Europe during 1990. Cooperation with Hungary has been underway for some time for the financing and construction of two 1,000-MWe-class PWRs to be operated by EdF for local consumption and for exports to neighboring countries. The French also signed two accords with their Soviet counterparts during 1990; the agreements call for collaboration to improve the Soviet power system, and to exchange nuclear operating information. To support the accords, EdF formally opened an office in Moscow in September. EdF also led the effort that created a European company, involving contributions from several western European utilities, to take a 15-percent share in VEAG, the new electric utility for the former German Democratic Republic.

EdF Uranium Activities

EdF ventured into the uranium production business in mid-1990, with the acquisition of Malapai Resources, the US uranium producer. The utility created a US subsidiary, Fuel International Trading Corporation (FITCO), based in Atlanta, Georgia to oversee the Malapai investment and pursue other fuel trading and mining activities in North America. Malapai, which has a long-term contract to supply U_3O_8 to EdF, is now operated by TOTAL Minerals (TOMIN), the US subsidiary of France's TOTAL Compagnie Minière, under a cooperative accord between FITCO and TOMIN.

Table 22
FRENCH ELECTRICITY IMPORT/EXPORT NET BALANCE[1]
1988-1990 (TWh)

	1988			1989			1990		
	Shared[2]	Other[3]	Total	Shared[2]	Other[3]	Total	Shared[2]	Other[3]	Total
Belgium/The Netherlands	- 0.8	3.9	3.1	- 1.3	4.9	3.6	- 1.3	4.5	3.2
Germany	2.7	0	2.7	2.3	- 0.6	1.7	2.6	1.3	3.9
Italy	0	9.6	9.6	0.6	10.8	11.4	0.2	12.7	12.9
Spain/Portugal	- 0.8	2.0	[illegible]	- 0.6	0.1	- 0.5	0	- 0.2	- 0.2
Switzerland	3.7	3.3	[illegible]	4.0	8.7	12.7	2.9	10.7	[illegible]
United Kingdom	0	13.0	13.0	0	13.0	13.0	0	11.9	11.9
Total	**4.8**	**32.1**	**36.9**	**5.0**	**37.2**	**42.2**	**4.4**	**40.9**	**45.3**

[1] *Source*: EdF

[2] Balance from cross-participation in power plants. (For example, France had a net import from Belgium and The Netherlands because of EdF's part ownership in Belgium's Tihange plant.)

[3] Other means straight sales, purchases, or exchanges of electricity.

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EdF reduced its uranium purchases during 1990 by eight percent compared to the previous year, buying approximately 6,500 MTU (17 million pounds U_3O_8) under long-term contracts. The utility's theoretical consumption amounted to 21 million pounds U_3O_8, so inventory drawdown covered a significant portion of requirements during the year. Uranium inventories in France remain high, and EdF is likely to continue reducing purchases until the mid-1990s. The utility reportedly agreed during 1990 with the Rössing uranium mine in Namibia, and with TOTAL, which has a share in Rössing, to defer some near-term deliveries while also consenting to buy a significant quantity of uranium in the 1995-2002 time frame.

Uranium Production

French domestic production amounted to 7.3 million pounds equivalent U_3O_8 in 1990, with about 85 percent controlled by Cogema and 15 percent by TOTAL. Cogema continued to streamline domestic operations, cutting back and eliminating production at a number of sites. Conventional production costs in France are high, but are supported by the government for national security reasons.

Cogema continued to pursue overseas mining investments, including a development plan for the Cigar Lake deposit in Saskatchewan, Canada, considered the richest deposit in the world. The company has key investments in COMINAK and SOMAIR in Niger, COMUF in Gabon, AMOK in Canada, Pathfinder Mines in the USA, and Pancontinental and Energy Resources of Australia, among others. Cogema discussed consultancy arrangements with Wismut SDAG in Germany and the state uranium production company in Czechoslovakia, thus expanding its influence in Europe. It also pursued a number of new US mining investments during 1990, including a bid for the uranium assets of Chevron Resources. TOMIN, the US subsidiary of TOTAL, operates a uranium production operation in Texas in a joint venture with Chevron.

Fuel Cycle Services

Natural UF_6 conversion by Comurhex declined significantly in 1990, with EdF, Comurhex's largest customer, cutting back its conversion purchases by about one-third. With the US dollar weakening throughout the year, and a continued excess of conversion capacity worldwide, the French convertor was unable to compensate with new export sales. On the other hand, the outlook for Comurhex's commercial UF_6 reconversion business, UREP, improved during 1990 with the inclination by several customers to convert reprocessed uranium for eventual recycling.

Eurodif's enrichment supply business suffered similarly, with EdF curtailing SWU purchases dramatically during 1990, in order to absorb excess stocks of enriched material. However, deliveries to EdF are expected to recover to the approximate level of requirements in 1991 and increase thereafter. Cogema handles international marketing for Eurodif, but has had limited success recently, given global SWU overcapacity and difficult market conditions. Eurodif's other shareholders in Spain and Italy are taking no new deliveries from the enricher, while the Belgian shareholder has optimized its supplies. The financial dispute between the Iranian government, which owns a share of Eurodif, and the French government remained unresolved in 1990.

The French government licensed Cogema's UP3 reprocessing plant at La Hague for commercial operation in 1990. The first spent fuel rods were sheared and dissolved in the UP3 head-end in August, and by the end of 1990 the facility had reprocessed about 220 MT of fuel. Cogema has contracts with European and Japanese utilities to reprocess 7,000 MT by the year 2000. Following the cancellation of Germany's reprocessing plant at Wackersdorf, Cogema signed several new reprocessing contracts with German utilities during 1990. Some of the plutonium from the French reprocessing plants will be manufactured in mixed-oxide assemblies at the new MELOX fabrication plant at Marcoule. EdF expects recycling eventually to account for up to 15 percent of French domestic fuel supply.

Plans for the long-term storage of radioactive wastes in France were upset during 1990 by public opposition. The government was forced to halt exploratory work at four potential repository sites.

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Table 23
NUCLEAR POWER UNITS IN FRANCE

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD [1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh Net)
Belleville 1	EdF[2]	1,310	PWR	1988	69	7,907
Belleville 2	EdF	1,310	PWR	1988	55	6,322
Blayais 1	EdF	910	PWR	1981	73	5,845
Blayais 2	EdF	910	PWR	1983	72	5,724
Blayais 3	EdF	910	PWR	1983	61	4,894
Blayais 4	EdF	910	PWR	1983	75	5,959
Bugey 1	EdF	540	GCR	1972	43	2,026
Bugey 2	EdF	920	PWR	1979	61	4,885
Bugey 3	EdF	920	PWR	1979	56	4,538
Bugey 4	EdF	900	PWR	1979	41	3,257
Bugey 5	EdF	900	PWR	1980	72	5,653
Cattenom 1	EdF	1,300	PWR	1987	61	7,938
Cattenom 2	EdF	1,300	PWR	1988	16	8,271
Chinon B1	EdF	870	PWR	1984	62	4,990
Chinon B2	EdF	870	PWR	1984	79	5,322
Chinon B3	EdF	905	PWR	1987	66	5,470
Chinon B4	EdF	905	PWR	1988	61	6,141
Chooz A	SENA[3]	305	PWR	1967	61	1,514
Cruas 1	EdF	880	PWR	1984	73	5,047
Cruas 2	EdF	915	PWR	1985	80	6,019
Cruas 3	EdF	880	PWR	1984	72	6,144
Cruas 4	EdF	880	PWR	1985	63	5,245
Dampierre 1	EdF	890	PWR	1980	83	2,251
Dampierre 2	EdF	890	PWR	1981	70	4,947
Dampierre 3	EdF	890	PWR	1981	76	6,056
Dampierre 4	EdF	890	PWR	1981	69	5,263
Fessenheim 1	EdF	880	PWR	1977	42	5,026
Fessenheim 2	EdF	880	PWR	1978	72	3,539
Flamanville 1	EdF	1,330	PWR	1986	78	7,126
Flamanville 2	EdF	1,330	PWR	1987	43	7,833
Gravelines B1	EdF	910	PWR	1980	64	4,484
Gravelines B2	EdF	910	PWR	1980	80	6,158
Gravelines B3	EdF	910	PWR	1981	79	6,127
Gravelines B4	EdF	910	PWR	1981	62	6,190
Gravelines C5	EdF	910	PWR	1985	75	6,019
Gravelines C6	EdF	910	PWR	1985	65	6,147

(continued on next page)

[1] COD = Commercial Operation Date

[2] EdF = Electricité de France

[3] Chooz Unit A is owned and operated by SENA (Société d'Energie Nucléaire Franco-Belge des Ardennes), owned 50-percent each by EdF and the Belgian utilities.

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Table 23
NUCLEAR POWER UNITS IN FRANCE
(continued)

Units In Operation
(continued)

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh Net)
Nogent sur Seine 1	EdF[2]	1,310	PWR	1988	58	6,686
Nogent sur Seine 1	EdF	1,310	PWR	1989	6	7,533
Paluel 1	EdF	1,330	PWR	1985	63	7,360
Paluel 2	EdF	1,330	PWR	1985	56	6,504
Paluel 3	EdF	1,330	PWR	1986	63	7,323
Paluel 4	EdF	1,330	PWR	1986	69	8,080
Penly 1	EdF	1,310	PWR	1990	—	3,003
Phénix	CEA[3]	233	LMFBR	1973	48	983
St Alban 1	EdF	1,335	PWR	1986	66	7,777
St Alban 2	EdF	1,335	PWR	1987	52	6,087
St. Laurent A2	EdF	450	GCR	1971	23	907
St. Laurent B1	EdF	915	PWR	1983	77	6,175
St. Laurent B2	EdF	880	PWR	1983	68	5,234
Superphénix	NERSA[4]	1,200	LMFBR	1986	6	613
Tricastin 1	EdF	915	PWR	1980	64	5,094
Tricastin 2	EdF	915	PWR	1980	70	5,640
Tricastin 3	EdF	915	PWR	1981	80	6,458
Tricastin 4	EdF	915	PWR	1981	65	5,240
TOTAL		**53,148**		*(1990 Average:*	**64)[5]**	**292,944**

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	Percent Complete[6]
Cattenom 3	EdF	1,300	PWR	1991	100
Cattenom 4	EdF	1,300	PWR	1991	100
Chooz B1	EdF	1,455	PWR	1993	75
Chooz B2	EdF	1,455	PWR	1994	51
Golfech 1	EdF	1,310	PWR	1991	100
Golfech 2	EdF	1,310	PWR	1993	80
Penly 2	EdF	1,310	PWR	1992	90
TOTAL		**9,440**			

[1] COD = Commercial Operation Date (actual or expected)

[2] EdF = Electricité de France

[3] CEA = Commisariat à l'Energie Atomique

[4] Superphénix is owned by NERSA, a European consortium of which the shareholders are EdF (51%), ENEL (33%), and SBK (16%). SBK is owned by RWE (West Germany, 68.75%), SEP (The Netherlands, 14.75%), Electronucléaire (Belgium, 16.5%) and NE (UK, 1.75%).

[5] Average does not include those units which entered commercial operation or were retired during 1990.

[6] Source: *Nuclear News*

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Figure 14
NUCLEAR POWER UNITS AND FUEL CYCLE FACILITIES IN FRANCE

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GERMANY

Unification in 1990

On October 3, 1990 the Federal Republic of Germany reunited with the German Democratic Republic (GDR), with mixed results for Germany's nuclear power industry. On the positive side, a large territory in need of economic development was opened to western German utilities and industry. Power demand and manufacturing orders have surged in what is now, by far, the most populous country in Europe west of the Soviet Union. On the other hand, the new Germany must cope with the remains of the GDR's ambitious nuclear industry, including its outmoded power plants and a vast uranium mining enterprise.

Under an agreement reached in August 1990, the territory of the GDR will be served by a new wholesale electric utility, Vereinigte Energiewerke AG (VEAG), based in Berlin and owned primarily by German and west European utilities. Among the investing companies, PreussenElektra (PREAG) and Bayernwerk AG (BAG), which have territories adjacent to the former GDR, each own about 25 percent of VEAG. RWE AG, which specializes in lignite power production in North-Rhine Westphalia, has another 25 percent. Fifteen percent of VEAG was purchased by a group of non-German utilities led by Electricité de France, with the remaining 10 percent held, for the time being, by the federal government trust for eastern Germany (Treuhandanstalt). Some 80 percent of electricity production in the former GDR is currently generated from lignite (brown coal); RWE will control the modernization of the lignite production system.

Existing nuclear power units in the former GDR are excluded from the new utility's mandate and are currently under the control of Germany's Economics Ministry (BFW). There are three nuclear plant sites for eleven units in eastern Germany, including a one-unit plant at Rheinsberg, an eight-unit station at Greifswald on the Baltic coast, and a two-unit station under construction at Stendal on the Elbe River. This compares to eighteen plant sites for 23 units in western Germany, with a total planned net capacity of 22,709 MWe, counting the Kalkar fast breeder reactor (**Table 24**).

Six operating units in the former GDR with 2,270 MWe of capacity, were shut down indefinitely during 1990 because of substantial design differences between the Soviet-supplied units and Western plants. Although it is conceivable the East German units could be modified to meet Western standards, it seems more likely the units will remain closed, given the uncertain political environment surrounding nuclear energy in Germany.

Nuclear Power Generation

Kraftwerk Union's (KWU) Convoy units continued their outstanding performance during 1990, claiming ten of the year's sixteen biggest producing power plants worldwide. Three units, Grohnde, Emsland and Neckarwestheim 2, each generated more than 10,000 GWh (gross) during the year. Philippsburg 2 (**Figure 15**) ranked tenth in the world, generating just under 9,000 GWh (gross) in 1990. Most of the large German units are used for baseload, running at full power year-round. Nuclear continued to account for more than one-third of western Germany's electricity generation during 1990.

Despite excellent operating results, average capacity use nationwide was about 71 percent, due in part to politically forced outages. Of western Germany's 23 completed power reactors, five were limited by political intervention during 1990: the THTR-300 and the Kalkar fast breeder, Mülheim-Kärlich, Würgassen, and Obrigheim. The ruling Social Democratic government in North-Rhine Westphalia has indefinitely blocked the restart of the THTR-300 and the licensing of the finished Kalkar plant. Both VEW, the lead shareholder in the THTR, and RWE, the main utility behind Kalkar, also appear ready to abandon those units. RWE's Mülheim-Kärlich unit, a 1,219-MWe pressurized water reactor that started operation in Rhineland-Palatinate in 1987, has been down since 1988 by court order due to a licensing technicality. Würgassen, located in Hesse and operated by PREAG, was forced down for nine months in 1990 for improvement of the fire security system. Germany's oldest commercial reactor, Obrigheim, was ordered down in May 1990 after 21 years of service, when a court ruled the unit had never received a long-term operating license. The authorities in Baden-Würtemberg, where Obrigheim is located, took the opportunity to demand several plant modifications, and the unit's future is now uncertain.

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Figure 15 Philippsburg 1 and 2 (an 864-MWe PWR and a 1,268-MWe BWR); Unit 2 ranked tenth in the world in gross electrical generation for 1990. *(Photo courtesy of Kernkraftwerk Philippsburg.)*

Uranium Production

With unification, Germany inherited from the GDR one of the world's largest uranium production enterprises: Wismut SDAG, a Soviet-GDR company based in Chemnitz (formerly Karl-Marx Stadt) near the CSFR-GDR border. Cumulative uranium production in the former GDR amounted to a staggering 575 million pounds U_3O_8 between 1946 and 1989, approximately the same historical production as in Canada. **Figure 17** shows Wismut's mine in the Königstein district.

In 1990, Wismut produced about 8.3 million pounds U_3O_8 from ore mined at seven underground locations and processed at the Seelingstadt mill. This production level represented a substantial decrease from previous years. All of the uranium is believed to have been exported to the Soviet Union under a long-term contract between Wismut and the Soviet Ministry for Atomic Energy and Industry (MAEI), which owns half of Wismut and has supplied much of the technical expertise for its operations. MAEI terminated the supply contract after 1990 and may be prepared to relinquish its share in Wismut. Because of low ore grade, production costs are prohibitively high by Western standards, and U_3O_8 production is planned to cease by 1995. The German Economics Ministry (BEW), which has responsibility for Wismut, is now focusing on the massive, costly restoration work necessary in the regions where Wismut has operated.

Table 24
NUCLEAR POWER UNITS IN GERMANY

Units In Operation or Shutdown Indefintely

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh Net)
Biblis A	RWE[2]	1,146	PWR	1975	51	5,091
Biblis B	RWE	1,240	PWR	1977	85	9,021
Brokdorf	PREAG[3]	1,326	PWR	1986	71	8,797
Brunsbüttel	HEW[4]	771	BWR	1977	71	4,791
Emsland	VEW[5]	1,242	PWR	1988	92	9,991
Grafenrheinfeld	BAG[6]	1,235	PWR	1982	87	7,916
Greifswald 1[7]	Treuhandanstalt	408	PWR	1974	—	—
Greifswald 2[7]	Treuhandanstalt	408	PWR	1975	—	—
Greifswald 3[7]	Treuhandanstalt	408	PWR	1978	—	—
Greifswald 4[7]	Treuhandanstalt	408	PWR	1979	—	—
Grohnde	PREAG	1,300	PWR	1985	89	10,127
Gundremmingen B	RWE	1,240	BWR	1984	79	8,532
Gundremmingen C	RWE	1,248	BWR	1985	76	8,292
Isar 1	BAG	870	BWR	1979	67	5,068
Isar 2	BAG	1,310	PWR	1988	81	9,343
Krümmel	HEW	1,260	BWR	1984	80	8,820
Mülheim-Kärlich	RWE	1,219	PWR	1987	0	0
Neckarwestheim 1	GKN[8]	795	PWR	1976	84	5,863
Neckarwestheim 2	GKN	1,230	PWR	1989	91	9,832
Obrigheim 1	KWO[9]	340	PWR	1969	39	1,170
Philippsburg 1	BW / EVS[10]	864	BWR	1980	69	5,196
Philippsburg 2	BW / EVS	1,268	PWR	1985	76	8,490
Rheinsberg 1[7]	Treuhandanstalt	70	PWR	1966	—	—
Stade	PREAG	640	PWR	1972	75	4,193
Unterweser	PREAG	1,230	PWR	1979	79	8,467
Würgassen	PREAG	640	BWR	1975	19	1,093
TOTAL		**24,116**		*(1990 Average:*	**71)**[11]	**140,087**

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	Percent Complete
Greifswald 5	Treuhandanstalt	408	PWR	Indefinite	100
Greifswald 6	Treuhandanstalt	408	PWR	Indefinite	90
Greifswald 7	Treuhandanstalt	408	PWR	Indefinite	60
Greifswald 8	Treuhandanstalt	408	PWR	Indefinite	50
Kalkar	SBK[12]	295	LMFBR	Indefinite	100
Stendal 1	Treuhandanstalt	900	PWR	Indefinite	—
Stendal 2	Treuhandanstalt	900	PWR	Indefinite	—

[1] COD = Commercial Operation Date (actual or expected)
[2] RWE = RWE Energie AG
[3] PREAG = Preussenelektra AG
[4] HEW = Hamburgische Elektricitätswerke AG
[5] VEW = Vereinigte Elektrizitätswerke W[illegible]en AG
[6] BAG = Bayernwerk AG
[7] Shutdown indefinitely
[8] GKN = Gemeinschaftskernkraftwerk Neckar GmbH
[9] KWO = Kernkraftwerk Obrigheim GmbH
[10] BW / EVS = Badenwerk AG / Energieversorgung Schwaben AG
[11] Average does not include those units shutdown infinitely, or which entered commercial operation or were retired during 1990.
[12] SBK = Schnell-Brüter Kernkraftwerksgesellschaft mbH

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Figure 16
GERMANY
NUCLEAR POWER UNITS AND FUEL CYCLE FACILITIES

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Figure 17 — Wismut's mine in the Königstein district, near Leopolishain. (*Photo courtesy of Wismut.*)

Uranerzbergbau, the other principal uranium mining company in Germany, through its Canadian affiliate Uranerz Exploration and Mining (UEM), bought one-third of the Rabbit Lake operation from Cameco in July 1990, essentially doubling its already substantial position in uranium-rich Saskatchewan. The Rabbit Lake mill was shut down for much of 1990 for mill modifications and to allow the owners to work off inventories in the depressed market environment. Mining operations have, however, continued in the Rabbit Lake district. At this time, the Rabbit Lake mill has the capacity to produce about twelve million pounds U_3O_8 per year, in addition to Key Lake's twelve-million-pound rating. UEM has long-term contracts with two German utilities, as well as with other European and US utilities.

Fuel Contracting

Three German utilities signed medium-term U_3O_8 supply contracts during 1990, and a fourth was negotiating new supplies in the first quarter 1991. Urangesellschaft mbH (UG), newly constituted in September 1989 from a merger with STEAG Kernenergie GmbH, was an active supplier, winning three of the four utilities' multi-year contracts. The other utility selected a Canadian producer. A fifth German utility contracted for substantial uranium quantities on the spot market during 1990. Germany's Ministry for Research and Technology (BMFT) began selling its large stockpile of DOE-origin enriched UF_6 in the second half of 1989, and continued that effort in 1990. The material was marketed cooperatively by Nukem GmbH and Urenco Ltd. to some European and US utilities. Nukem and Urenco both have longstanding ties to BMFT from nuclear research programs of the 1970s and 1980s. BMFT is expected to sell the remainder of the stockpile, estimated to contain almost one million SWU, via Nukem and Urenco during 1991.

German utilities have contracts with a range of suppliers for conversion and enrichment, although US sources have been shunned in recent years because of safeguards obligations imposed by the US government. Urenco covers a little more than half of Germany's enrichment requirements. Urenco's enrichment production capacity currently amounts to 2.5 million SWU at its plants in Germany, the UK, and The Netherlands, while its customer base consists mainly of German, British, Dutch, Swedish, and Swiss utilities.

Following the cancellation in 1989 of the Wackersdorf reprocessing facility in Bavaria, German utilities entered into long-term reprocessing contracts with Cogema and BNFL during 1990. Cogema agreed to reprocess fuel from fifteen reactors, while BNFL obtained commitments from seven reactors. German utilities are required under the German Atomic Law to have reprocessing contracts. Nevertheless, several of the utilities openly questioned the law during 1990, and only reluctantly signed the costly long-term reprocessing contracts.

Germany has nominated three sites for long-term disposal of radioactive wastes:

- The Konrad iron ore mine near Braunschweig, Lower Saxony, for low-level wastes.
- The Gorleben salt dome in Lower Saxony, for spent fuel products.
- The Morsleben salt mine in Saxony, in the former GDR, for low and intermediate wastes.

Detailed site work at Konrad and Gorleben has been technically positive, but political obstacles have delayed licensing. The German utilities need a repository for spent fuel products beginning in 1994 to store wastes returned from their reprocessing contracts.

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HUNGARY

During 1990, four Soviet-designed vodo-vodyanoi energetichesky reaktors (VVER) having a total capacity of 1,660 MWe, operated at the Paks station in central Hungary, contributing a significant share of the country's electricity. While the Paks units have a remarkable 86 percent lifetime load factor, a continuing upgrade and refurbishment program has been underway since 1986. Plans for two additional VVER-1000s were cancelled in 1990, and plans for five CANDU (heavy water) reactors, totalling approximately 5,000 MWe, were suspended. Instead, the government is evaluating proposals to build approximately 2,000 MWe of generation, based on either lignite in northeastern Hungary or nuclear at Paks, with a decision due in mid-1991. If nuclear is selected, the reactors would be financed by loans from the supplier country. In September 1990, the United States and Hungary signed a full nuclear cooperation agreement, that will be submitted for approval to the US Congress early in 1991. The agreement is needed for US vendors to compete for the Paks nuclear addition.

During 1990 Mecsek Ore Mining company concluded a joint venture agreement with Glencar Exploration plc of Ireland to redevelop and manage the Pecs mine. As a result, the Hungarian government reversed its 1989 decision to phase out domestic uranium production. Of the five underground mines at Pecs, two are now exhausted, but the remaining three are capable of producing more than 1.3 million pounds equivalent U_3O_8 per year. As the major partner in the joint venture, Glencar will manage the mine, in operation since 1958. The Hungarian government will spend approximately US$8 million in extraordinary relief for retraining or early retirement for nearly 1,300 of the 4,200 workers currently employed in Mecsek's uranium production division.

The Paks power station agreed early in 1991 to continue buying uranium from Mecsek for the foreseeable future and to continue purchasing fuel cycle services from the Soviet Union.

ITALY

The Italian Parliament voted in June 1990 to close permanently the nation's last two operational nuclear power stations. The 260-MWe pressurized water reactors at Trino Vercellese and the 860-MWe boiling water reactor at Caorso were down for refueling when Italy's November 1987 antinuclear referendum was passed; the units were never returned to service.

Following the Iraqi invasion of Kuwait, the Italian Prime Minister said that the elimination of nuclear power in Italy must be reconsidered, and that earlier anti-nuclear decisions had been short-sighted. Electricity consumption has grown 4 to 5 percent per year in recent years, and imports of electricity, primarily from France and Switzerland, have grown to 15 percent of Italy's annual requirements.

AGIP S.p.A. and Ente Nazionale di Energia Elettrica (ENEL) have substantially reduced their activities in the nuclear fuel market in recent years, although Italian entities retain a cumulative 16-percent share in Eurodif. The Italian government also continues to support research on advanced reactor systems in collaboration with other nations and companies.

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EUROPE

THE NETHERLANDS

Dutch utilities continued to consolidate during 1990 as Provinciale N.V. Zeeuwse Energie-Maatschappij (PZEM), owner of the Borssele nuclear power plant, merged with two other south Netherlands utilities to form NV Electriciteits-Produktiemaatschappij Zuid-Nederland (EPZ). There are now four principal generating companies in the Netherlands: EPZ in the south; EZH around Rotterdam; UNA around Amsterdam; and EPON in the large northeastern region. The Netherland's two operating nuclear units, the 452-MWe Borssele pressurized water reactor and the 56-MWe Dodewaard boiling water reactor, achieved gross capacity factors of 85 and 73 percent, respectively, in 1990. These plants supplied about six percent of Dutch electricity.

Although the Dutch Ministry of Economics has a positive view toward nuclear power, recent polls of public opinion indicate about 85 percent of the public oppose expansion of the nuclear program. No revival of the nuclear building program is expected until after the next parliamentary elections in 1995.

EPZ continues to purchase its natural uranium from the spot market. Its enrichment needs are covered by a requirements contract with Urenco, which operates an enrichment plant in The Netherlands. The Dutch have reprocessing contracts with Cogema of France.

POLAND

In September 1990, the Polish government voted to abandon its only nuclear power plant project at Zarnowiec and put a moratorium on any further nuclear development until the year 2000. The government cited technical, financial, and political considerations in making the decision. A study performed by Belgatom and Tractebel of Belgium found that an additional US$1 billion would be needed to complete the two units under construction at Zarnowiec. Poland currently has no nuclear fuel cycle facilities of any kind. Uranium production was carried out along the Czechoslovakian border from 1948 until 1965.

PORTUGAL

Empresa Nacional de Uranio (ENU), Portugal's sole uranium producer, produced approximately 400 thousand pounds equivalent U_3O_8 in 1990. The long-term supply contract between ENU and Electricité de France (EdF) is not expected to be renewed when it expires in 1991. ENU has applied for European Community support to maintain its production after 1991, in light of its relatively high costs in the current depressed market.

Portugal has no domestic nuclear power at present, and had no plans to develop any. A tripartite electricity supply agreement with France and Spain, finalized in early 1991, will provide Portugal with 312 MWe per year of electricity supply for up to ten years, beginning in 1994.

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ROMANIA

Construction remained suspended during 1990 on Romania's five CANDU (heavy water) nuclear power units at Cernavoda on the Danube River. Although the Romanian government has designated the completion of Cernavoda a national priority, construction has been frozen since late 1989, pending verification and documentation of work already completed. The suspension has allowed repairs to be made on the first two units, which are about 50-percent complete, bringing the units close to Western standards. At the Romanian government's request, an International Atomic Energy Agency team recently completed the first of three inspections of the Cernavoda site and found that, while the project "has the advantage of using a well-advanced western technology" with "a framework of safety regulations" provided by Romania, the project has been developed with limited industrial and material resources and "the shortcomings of the past centralized system". Atomic Energy of Canada Ltd. (AECL) recently has taken over the on-site management at Cernavoda; previously, AECL had only provided technical assistance, with on-site management done by the Romanians.

Financing of the project may not be a prohibitive problem, as Romania has a relatively low level of foreign debt, and earlier loans from Canada were paid off more than a year ago. New financing discussions with Canadian banks are underway. While Romania has not made any further statements regarding its nuclear plans, a nuclear expansion program likely will be included in the government's energy plans.

Romania held free elections in May 1990, resulting in an overwhelming mandate for the National Salvation Front and its leader, Ion Ilescu, a former senior Communist Party official. The government plans to restructure the economy over a seven-year period.

Romania has three uranium production areas: the Brasov area in central Romania; the Bistritei Mountains in the north; and the Almas Mountains in the southwest. Domestic production is estimated at about 2.6 million pounds equivalent U_3O_8 annually. In addition, Romania can produce UO_2 powder and, under license from Canada, plans to produce its own fuel assemblies for the CANDU reactors.

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SOVIET UNION

Nuclear Power Production

Nuclear power development in the Soviet Union continued to be scaled back during 1990. The country's 1985 plan to have 200,000 MWe in operation by 2000 was revised during the year to 50,000-80,000 MWe by 2005. With 47 reactors in commercial operation, however, the Soviet Union remains the third-largest nuclear generating country in the world after the USA and France (**Table 25**).

Nuclear energy provided about 13 percent of total electricity production in the Soviet Union in 1990, about the same level as 1989. Although new facilities did enter operation, the added capacity was offset by the retirement of older reactors.

Of the operating reactors, 25 are vodo-vodyanoi energetichesky reaktors (VVER) (pressurized water reactors), 20 are RBMKs (graphite moderated, water cooled) and two are liquid metal fast breeder reactors (LMFBR). Of the VVERs, eight are "first generation", four are "second generation", and eighteen are of the VVER-1000 class. The twelve first and second generation reactors were built without a containment building.

Two reactors entered commercial operation in 1990: Zaporozhe 5, a 950-MWe VVER in the Ukraine, and Smolensk 3, a 925-MWe RMBK near the border of Belorussia and Russia. Smolensk 3 is the first RBMK-type reactor to start up since the Chernobyl accident in 1986.

Armenia 1 and 2, both first generation VVER-400s, were shut down during 1990. In addition, six RMBK-1000 reactors—Chernobyl 1 and 2, Kursk 1 and 2, and Leningrad 1 and 2—were downrated to 700 MWe to improve safety margins for operation, resulting in a substantial loss of generating capacity.

In the Ukraine, the Ukrainian Parliament passed a five-year moratorium halting all planning and construction on nuclear plants. Work has stopped on eight reactors, three of which would have come on line during 1990. Two VVER-1000 reactors under construction near the city of Volgodonsk, scheduled to enter service in 1990-1991, have been halted due to local opposition; the units are being considered for conversion to gas. An additional safety concern for VVER-1000-class reactors also emerged during the year. During the early portion of the operating cycle, these reactors have been found to be unstable and therefore can only be operated at a reduced power level. The problem will be resolved by modifications in future refueling patterns; however, it again reduces the generating capacity available at this time. On a more positive note, an International Atomic Energy Agency safety review team found that the Ignalina station, consisting of two large capacity channel reactors (RBMK-1500s), was being operated "...at an internationally acceptable level".

In Chelyabinsk, Russia, the regional council voted overwhelmingly to resume construction on the two BN-800 LMFBRs however, a local referendum will be held on the matter. Public opposition to nuclear is strong in the region because of a substantial amount of nuclear waste remaining from the last military production reactor at Mayak, in the Chelaybinsk region, which was closed in September 1990.

Throughout the Soviet Union, first and second generation reactors must be brought into compliance with current safety standards. To accomplish this task, the Soviet Union, with the assistance of the World Association of Nuclear Operators and other Western organizations, has initiated a program to improve reactor safety. This program, when carried out, will reduce the probability of a severe accident to a level comparable with countries in western Europe.

Other efforts aimed at addressing safety issues were made in 1990, including the establishment of the USSR Nuclear Society, with ties to the American Nuclear Society and the European Nuclear Society. Also the Soviet Union and the USA signed an agreement to cooperate in the area of decontamination and decommissioning, as well as nuclear waste management. A new agreement with France calls for broad cooperation in nuclear matters, including improved safety of Soviet nuclear facilities, nuclear waste management, decommissioning, dismantling, training, and development of future reactor types. A breeder reactor technology cooperation agreement was signed with Argentina, and the Soviet Union and Japan signed a memorandum of cooperation relating to the Chernobyl accident.

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Nuclear Fuel Production

The Soviet Union is rich in natural resources. In addition to being the world's largest producer of steel and oil, it also produces a substantial share of the world's copper, gold, lead, molybedenum, nickel, silver, and uranium. A significant portion of uranium in the country is recovered through by-product or co-product mining operations, or by in-situ leaching (approximately 20 percent of production). Uranium is recovered from the production of phosphates; lignite; and precious, base, and specialty metals.

Uranium production in the Western World totalled 2.4 billion pounds U_3O_8 for the period 1946-1989. East European production is now known to have exceeded 1.4 billion pounds during that same period. It is estimated that approximately one-half of that amount was produced by the Soviet Union, while the remaining production was shipped to the Soviet Union. The Soviet Union continues to be active in the uranium production industry. During 1990, the following eight production centers were reported in operation, although the Eastern Works was closed in 1991 (**Figure 19**):

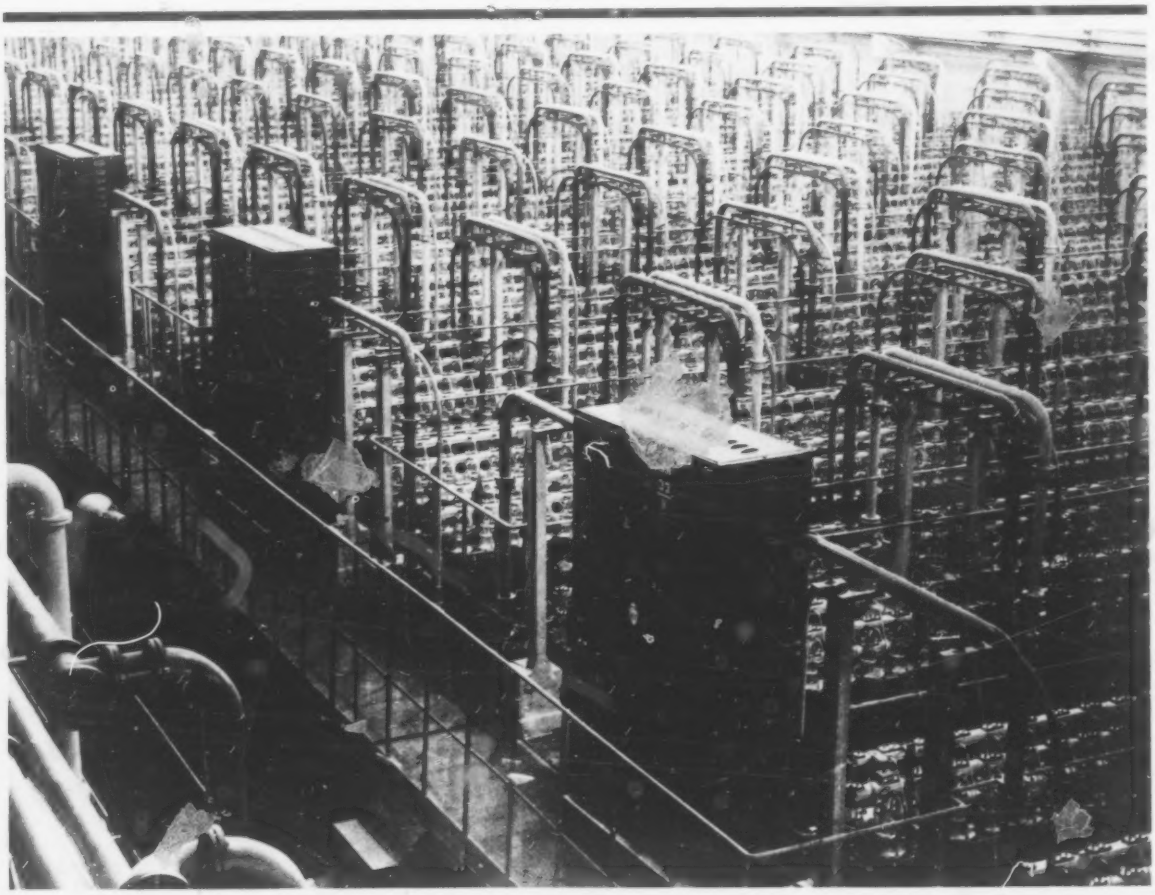

Figure 18 — Interior view showing cascades at an operating gas centrifuge plant.
(Photo courtesy of the Ministry of Atomic Energy and Industry.)

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NUEXCO

EUROPE

1. Eastern Works (Zholtye Vody, Ukraine)
2. Bykogorsk (Cauc[illegible] region, Russia).
3. Caspian (western K[illegible]an).
4. Navoi (Uzbekistan).
5. Leninabad (Tadzhikistan).
6. Kirghiz (Kirghizia).
7. Tselinnij (north-central Kazakhstan).
8. Argun (Russia, near the eastern border with China and Mongolia).

These production centers are not solely uranium mills, but are portions of large metallurgical complexes that deal with several different mineral commodities.

The Soviet Union began developing UF_6 conversion technology in 1947 and uranium enrichment technology in 1949. Industrial-scale uranium enrichment began in 1949, using the gaseous diffusion method to produce material for nuclear weapons. By the early 1960s, centrifuge technology was in use on an industrial scale. Production of highly enriched weapons-grade uranium was completely halted in 1987. At present the Soviet Union is operating four enrichment plants (at classified locations), two of which also have facilities for conversion of concentrates to UF_6 (**Figure 18**). All four enrichment plants have gas centrifuge units, and enrichment provided by gaseous diffusion accounts for less than five percent of their total output.

The Soviet Union began selling enrichment services to west European customers in 1971, and deliveries to Western customers began in 1973. In the mid-1970s, V/O Techsnabexport (TENEX), the marketing arm of the Ministry for Atomic Energy and Industry, concluded contracts with firms in almost all west European countries. TENEX continued to market Soviet uranium, conversion, and enrichment services during 1990. The extent of TENEX's export potential is not known outside the Soviet Union, but total uranium exports in all forms during 1990 increased, relative to 1989. TENEX currently fulfills all of eastern Europe's demand for enrichment services, as well as about ten percent of the demand of the European Community.

TENEX signed several notable contracts in 1990, including a series of long-term SWU contracts with the four Yankee utilities in the USA, and a long-term enriched UF_6 contract with Korea Electric Power Company. The Yankee contracts involve up to four million SWU for delivery during the period 1994–2002.

Also in 1990, the long-term contract arrangements between the Soviet Union and Czechoslovakia, Bulgaria, and Hungary came under review. The Soviets decided to require dollar-based payments from the former COMECON members, and will no longer accept the return of spent fuel elements under new contracts.

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Table 25
NUCLEAR POWER UNITS IN THE SOVIET UNION

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD [1]
Balakovo 1	MAEI [2]	950	VVER [3]	1986
Balakovo 2	MAEI	950	VVER	1988
Balakovo 3	MAEI	950	VVER	1989
Beloyarsk 3	MAEI	560	LMFBR [4]	1981
Chernobyl 1	MAEI	650	RBMK [5]	1978
Chernobyl 2	MAEI	650	RBMK	1979
Chernobyl 3	MAEI	925	RBMK	1982
Ignalina 1	MAEI	1,380	RBMK	1985
Ignalina 2	MAEI	1,380	RBMK	1989
Kalinin 1	MAEI	950	VVER	1985
Kalinin 2	MAEI	950	VVER	1987
Khmel'nitski 1	MAEI	950	VVER	1988
Kola 1	MAEI	411	VVER	1973
Kola 2	MAEI	411	VVER	1975
Kola 3	MAEI	411	VVER	1982
Kola 4	MAEI	411	VVER	1984
Kursk 1	MAEI	650	RBMK	1977
Kursk 2	MAEI	650	RBMK	1979
Kursk 3	MAEI	925	RBMK	1984
Kursk 4	MAEI	925	RBMK	1986
Leningrad 1	MAEI	650	RBMK	1974
Leningrad 2	MAEI	650	RBMK	1976
Leningrad 3	MAEI	925	RBMK	1980
Leningrad 4	MAEI	925	RBMK	1981
Novovoronezh 2	MAEI	336	VVER	1970
Novovoronezh 3	MAEI	385	VVER	1972
Novovoronezh 4	MAEI	385	VVER	1973
Novovoronezh 5	MAEI	950	VVER	1981
Rovno 1	MAEI	361	VVER	1981
Rovno 2	MAEI	384	VVER	1982
Rovno 3	MAEI	950	VVER	1987
Smolensk 1	MAEI	925	RBMK	1983
Smolensk 2	MAEI	925	RBMK	1985
Smolensk 3	MAEI	925	RBMK	1990
South Ukraine 1	MAEI	950	VVER	1983
South Ukraine 2	MAEI	950	VVER	1985
South Ukraine 3	MAEI	950	VVER	1989

(continued on next page)

[1] COD = Commercial Operation Date
[2] MAEI = Ministry of Atomic Energy and Industry
[3] VVER = Vodo-Vodyanoi Energetichesky Reaktor
[4] LMFBR = Liquid Metal Fast Breeder Reactor
[5] RBMK = Reaktory Bolshoi Moshchnosti Kanalnye

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Table 25
NUCLEAR POWER UNITS IN THE SOVIET UNION
(continued)

Units In Operation
(continued)

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]
Troitsk 3	MAEI	90	RBMK	1960
Troitsk 4	MAEI	90	RBMK	1960
Troitsk 5	MAEI	90	RBMK	1961
Troitsk 6	MAEI	90	RBMK	1963
Zaporozhe 1	MAEI[2]	950	VVER[3]	1985
Zaporozhe 2	MAEI	950	VVER	1985
Zaporozhe 3	MAEI	950	VVER	1987
Zaporozhe 4	MAEI	950	VVER	1988
Zaporozhe 5	MAEI	950	VVER	1989
BN–350	SCAE[4]	135	LMFBR[5]	1973
TOTAL		**33,810**		

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]
Balakovo 4	MAEI	950	VVER	1992
Balakovo 5	MAEI	950	VVER	1995
Balakovo 6	MAEI	950	VVER	1998
Kalinin 3	MAEI	950	VVER	1993
Kalinin 4	MAEI	950	VVER	1995
Khmel'nitski 2	MAEI	950	VVER	1990
Kostroma 1	MAEI	950	VVER	1994
Kostroma 2	MAEI	950	VVER	1995
Kursk 5	MAEI	925	RBMK[6]	1995
Tatar 1	MAEI	950	VVER	1994
TOTAL		**9,475**		

[1] COD = Commercial Operation Date (actual or expected)
[2] MAEI = Ministry of Atomic Energy and Industry
[3] VVER = Vodo-Vodyanoi Energetichesky Reaktor
[4] SCAE = State Committee for Atomic Energy
[5] LMFBR = Liquid Metal Fast Breeder Reactor
[6] RBMK = Reaktory Bolshoi Moshchnosti Kanalnye

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Figure 19
Nuclear Power Stations and Uranium Production Facilities in the Soviet Union

1 Kola ■■■■
2 Leningrad ✱✱✱✱
3 Kalinin ■■□□
4 Ignalina ✱✱
5 Smolensk ✱✱✱
6 Rovno ■■■

7 Chernobyl ✱✱✱
8 Khmel'nitski ■□
9 Kursk ✱✱✱✱✱
10 Novovoronezh ■■■■
11 Zaporozhe ■■■■■
12 South Ukraine ■■■

13 Balakovo ■■■□□□
14 BN-350 (Schevchenko) ▮▮
15 Troitsk ✱✱✱✱
16 Beloyarsk ▮▮

① Eastern Works ✣
② Bykogorsk ✣
③ Caspian ✣
④ Navoi ✣
⑤ Leninabad ✣
⑥ Kirghiz ✣
⑦ Tselinnij ✣
⑧ Argun ✣

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Table 25
NUCLEAR POWER UNITS IN THE SOVIET UNION

Units Shutdown, Cancelled, or Indefinitely Deferred

Unit	Capacity (MWe net)	Type	COD [1]	Shut Down [2]	Year Cancelled [3]
Aktash 1	950	VVER [4]	1989 c	—	1989
Aktash 2	950	VVER	1991 c	—	1989
Armenia 1	376	VVER	1979	1989	—
Armenia 2	376	VVER	1980	1989	—
Azerbaijan	950	VVER	1998 p	—	1988
Bashkir 1	950	VVER	1991 c	—	1990
Bashkir 2	950	VVER	1992 c	—	1990
Beloyarsk 1	102	RBMK [5]	1964	1983	—
Beloyarsk 2	146	RBMK	1969	1989	—
Chernobyl 4	925	RBMK	1984	1986	—
Chernobyl 5	925	RBMK	1991 c	—	1989
Chernobyl 6	925	RBMK	1992 c	—	1989
Georgia	950	VVER	1998 p	—	1989
Ignalina 3	1,380	RBMK	1994 p	—	1989
Ignalina 4	1,380	RBMK	1995 p	—	1989
Khmel'nitski 3	950	VVER	1991 c	—	1990
Khmel'nitski 4	950	VVER	1992 c	—	1990
Khmel'nitski 5	950	VVER	2000 p	—	1989
Krasnodar 1	950	VVER	1992 p	—	1988
Kursk 6	925	RBMK	1996 c	—	1989
Minsk 1	925	VVER	1988 c	—	1988
Minsk 2	925	VVER	1991 c	—	1988
Novovoronezh 1	265	VVER	1964	1988	—
Odessa 1	925	VVER	1989 c	—	1988
Odessa 2	925	VVER	1990 c	—	1988
Rostov 1	950	VVER	1990 c	—	1990
Rostov 2	950	VVER	1992 c	—	1990
Rostov 3	950	VVER	1995 c	—	1990
Rostov 4	950	VVER	1996 c	—	1990
Rovno 4	950	VVER	1991 c	—	1990
Smolensk 4	925	RBMK	1990 c	—	1989
South Ukraine 4	950	VVER	1991 c	—	1990
Troitsk 1	90	RBMK	1958	1987	—
Troitsk 2	90	RBMK	1959	1987	—
Zaporozhe 6	950	VVER	1992 c	—	1990
BN–800	750	LMFBR [6]	1996 c	—	1990
BN–1600	1,500	LMFBR	1996 p	—	1989
TOTAL	**30,930**				

[1] COD = Commercial Operation Date (actual or expected)
c = construction started on unit; p = unit was still in planning stage

[2] Year of shutdown if unit reached commercial operation

[3] Year when plans were cancelled or when construction was halted if unit did **not** reach commercial operation.

[4] VVER = Vodo-Vodyanoi Energetichesky Reaktor

[5] RBMK = Reaktory Bolshoi Moshchnosti Kanalnye

[6] LMFBR = Liquid Metal Fast Breeder Reactor

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SPAIN

Spain's nine operating nuclear reactors achieved an average capacity factor of 83 percent in 1990, supplying about 40 percent of the country's electricity (**Table 26**). With domestic power demand growing at over five percent per year, some experts forecast power shortages by 1994, and believe an additional 1,000 MWe of generating capacity will be needed each year from 1994 through 2005. Such forecasts are increasing pressure to resume construction on the two partially-complete nuclear units at Valdecaballeros. Under Spain's 1984 national energy plan, Valdecaballeros was indefinitely deferred but was to be maintained for possible resumption of construction. A new national energy plan is scheduled for 1992, at which time the plant's future will be decided.

To minimize the risk of future power shortages, Spanish utilities signed supply contracts with France for the

Table 26
NUCLEAR POWER UNITS IN SPAIN

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD [1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh net)
Almaraz 1	ENUSA[2]	895	PWR	1981	82	6,441
Almaraz 2	ENUSA	895	PWR	1984	97	7,612
Asco 1	ENUSA	930	PWR	1983	81	6,605
Asco 2	ENUSA	930	PWR	1986	85	6,894
Cofrentes	ENUSA	939	BWR	1985	85	7,015
Garona	ENUSA	440	BWR	1971	67	2,567
Jose Cabrera[3]	ENUSA	153	PWR	1969	72	964
Trillo 1	ENUSA	990	PWR	1988	76	6,560
Vandellos 2	ENUSA	943	PWR	1988	89	7,353
TOTAL		**7,115**		*(1990 Average:*	**83)[4]**	**52,011**

Units Deferred

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	Percent Complete[5]
Valdecaballeros 1	ENUSA	930	BWR	71
Valdecaballeros 2	ENUSA	975	BWR	58
Lemoniz 1	Iberduero	900	PWR	97
Lemoniz 2	Iberduero	900	PWR	57
TOTAL		**3,705**		

[1] COD = Commercial Operation Date
[2] ENUSA = Empresa Nacional del Uranio SA
[3] Also known as Zorita
[4] Average does not include those units which entered commercial operation or were retired during 1990.
[5] Source: Nuclear News

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equivalent of 1,000 MWe of power per year for a period of ten years. The imports depend on completion of a US$55 million transmission line from France to Spain. In addition, the utility Nuclenor announced a life extension program for the 440-MWe boiling water reactor at Santa Maria de Garona. The Garona unit has been in service since 1971, and the program is intended to extend its life from 2011 to 2031.

In May 1990, the government announced the permanent closure of the Vandellos 1 nuclear unit, shut down in October 1989 following a fire. This decision was based on the excessive costs of plant repair and modernization. The decommissioning cost for Vandellos 1 has been estimated at US$800 million.

Uranium Supply

Construction of a new uranium concentrates production plant at Saelices el Chico (**Figure 20**), near Ciudad Rodrigo, began in 1990. When completed, Empresa Nacional del Uranio (ENUSA) will be able to supply the majority of Spain's uranium requirements from domestic mining. ENUSA currently plans to expand conventional mining steadily over the coming years. ENUSA is also a shareholder in COMINAK, owner of the Akouta mine in Niger.

ENUSA has contracts with a variety of suppliers for conversion services and buys most of its enrichment from DOE and Techsnabexport. Although ENUSA is a shareholder in Eurodif, it will not be purchasing significant quantities in the coming years. ENUSA operates a fuel fabrication facility in northern Spain.

Figure 20 — Blasting at the Ciudad Rodrigo uranium mine. (*Photo courtesy of ENUSA.*)

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SWEDEN

Sweden's twelve operating reactors generated approximately 50 percent of the country's electrical power in 1990. During the year, the nominal power output of the two largest Swedish reactors, Oskarshamn 3 and Forsmark 3, was upgraded to about 1,160 MWe, from the previous nominal output of about 1,065 MWe each (**Table 27**). Likewise, over the past few years, most of the other Swedish reactors have been similarly upgraded; the resulting total output increase has been approximately 600 MWe, or about 6 1/2 percent of the total.

Sweden's energy policy drew continued criticism in 1990. The policy was not planned and developed in a piecemeal fashion in the early 1980s. Under the policy set forth by Sweden's Social Democratic government, the first two of Sweden's twelve reactors were to have been shut down by 1995-1996, and a complete phase-out of nuclear power was to occur by 2010. Also in the 1980s, laws were passed that limited increases in total CO_2 emissions, and banned any new large-scale hydroelectric development. But by 1989 and 1990, the economic problems associated with eliminating current capacity and halting new capacity additions led to heavily-publicized debates on energy policy. In late 1989, the government appointed a committee to reconcile the various opposing viewpoints.

Table 27
NUCLEAR POWER UNITS IN SWEDEN

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh net)
Units In Operation						
Barsebäck 1	Sydkraft	595	BWR	1975	82	4,284
Barsebäck 2	Sydkraft	595	BWR	1977	79	4,174
Forsmark 1	SSPB[2]	970	BWR	1980	73	6,219
Forsmark 2	SSPB	970	BWR	1981	75	6,375
Forsmark 3	SSPB	1,160	BWR	1985	84	7,857
Oskarshamn 1	OKG[3]	440	BWR	1972	64	2,476
Oskarshamn 2	OKG	605	BWR	1975	76	4,041
Oskarshamn 3	OKG	1,160	BWR	1985	75	7,596
Ringhals 1	SSPB	795	BWR	1976	68	4,479
Ringhals 2	SSPB	860	PWR	1975	72	5,069
Ringhals 3	SSPB	915	PWR	1981	74	5,896
Ringhals 4	SSPB	915	PWR	1983	81	6,510
TOTAL		**9,980**		***(1990 Average:***	**76)**	**64,976**

[1] COD = Commercial Operation Date
[2] SSPB = Swedish State Power Board. Forsmark Kraftsgrupp AB (FKA) is the owner of the plant, while SSPB is the operator and fuel purchaser. SSPB owns 74.5 percent of FKA.
[3] OKG = OKG Aktiebolag

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EUROPE

Finally, in January 1991, three of Sweden's major political parties—Social Democrat, Liberal, and Center—announced that they had reached an agreement on a plan to phase out nuclear power in their country. The new agreement delays the start of the phase-out into the next century. The agreement also calls for an investment of nearly US$1 billion in development of renewable energy sources and conservation measures. Additionally, the new strategy changes the policy on CO_2 emissions, calling for a strategy to stabilize the level of global warming emissions by the year 2000. The energy policy still must be ratified by the Parliament.

The Swedish utilities procured uranium from diverse long-term and spot sources in 1990, with most of the material coming from Australia and Canada. Enrichment needs continue to be met, in roughly equal amounts, from Eurodif, Urenco, DOE, Techsnabexport, and spot market purchases.

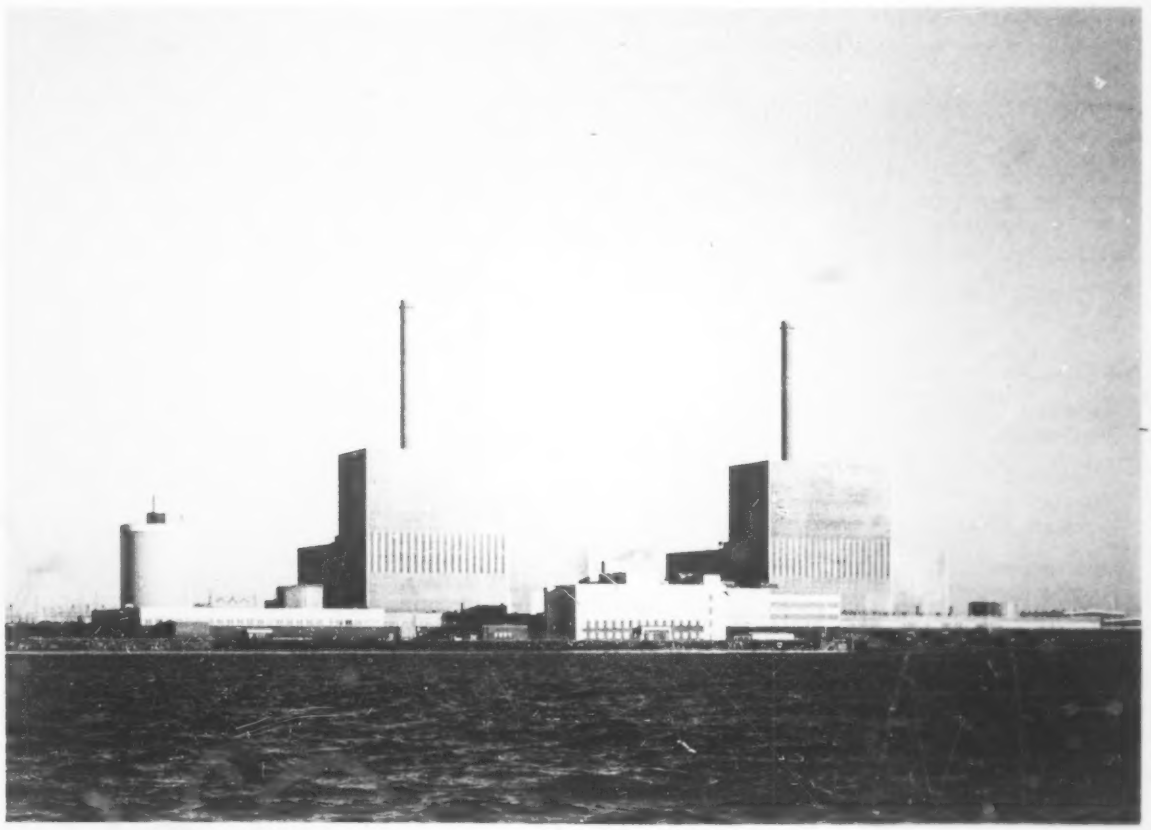

Figure 21— Sydkraft's Barsebäck units 1 and 2 (595-MWe BWRs) located on the southern coast of Sweden. *(Photo courtesy of Sydkraft.)*

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SWITZERLAND

Switzerland's five installed nuclear power units averaged 87-percent capacity utilization in 1990 (**Table 28**) and supplied about 40 percent of the country's total electricity generation. The balance of the country's generation is provided by hydropower. Additional power is imported from France, both from nuclear plants in which the Swiss have an ownership interest and from other contracts.

In a national referendum on September 23, 1990, by a vote of 53 percent to 47 percent, the Swiss rejected an initiative to phase out the use of nuclear energy as soon as possible. This was the third time in ten years that the Swiss have voted against a phase-out of nuclear energy. However, at the same time, the electorate did approve a ten-year moratorium on construction and operation of new nuclear power plants, by a vote of 55 percent to 45 percent.

Late in the year, Bernische Kraftwerke (BKW) applied to Swiss authorities for a new operating license for the Muehleberg nuclear power plant to replace the present provisional license that expires in 1992. The new license will be valid for an unlimited time. In support of its application, BKW submitted a new safety analysis report reflecting the improvement in plant safety provided by the new bunkered safety system (SUSAN) placed into operation during the year. Nordostschweizerische Kraftwerke's (NOK) Beznau Unit 2 is also being provided with a new bunkered safety system as a prerequisite for NOK's application for an unlimited operating license. Unit 2's provisional license expires in 1993. Although Beznau Unit 1 already has an operating license with a validity unlimited in time, it will also be served by the new bunkered safety system, assuring a similar level of backup safety features for both units.

The Swiss utilities continued to maintain comfortable uranium stockpiles during 1990. NOK, Kernkraftwerk Gösgen-Daniken, and Kernkraftwerk Leibstadt all participate in US uranium mining projects, and BKW holds an inventory in the USA. The utilities purchased enrichment from DOE and European enrichers during the year.

Siting of a depository for radioactive wastes continued to be a controversial issue in 1990. However, support increased for constructing an intermediate disposal facility for all categories of nuclear wastes at the Paul Scherrer Institute at Würenlingen. The Swiss utilities applied for federal permission in August to build such a facility, and the local community had previously voted to support such a project. The Zurich cantonal authorities gave their support to the project in December 1990. However, thousands of objections have been filed from individuals in Switzerland and in the neighboring German state of Baden-Würtemberg. It may take up to two years to conclude all required hearings before a final decision can be reached and the permit issued for construction.

In the mid-1990s the Swiss are scheduled to start receiving from France high-level, encapsuled wastes derived from reprocessed Swiss nuclear fuel. Such wastes would be given temporary storage in the new, intermediate-storage facility, pending construction of a final storage repository to be available by about 2020.

Table 28
NUCLEAR POWER UNITS IN SWITZERLAND

Unit	Lead Utility or Fuel Buyer	Units In Operation: Capacity (MWe net)	Type	COD[1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh net)
Beznau 1	NOK[2]	350	PWR	1969	83	2,546
Beznau 2	NOK	350	PWR	1971	85	2,618
Gösgen	KKG[3]	940	PWR	1979	87	7,200
Leibstadt	KKL[4]	990	BWR	1984	88	7,611
Mühleberg	BKW[5]	322	BWR	1972	87	2,459
TOTAL		**2,952**		*(1990 Average:*	**87)**	**22,434**

[1] COD = Commercial Operation Date
[2] NOK = Nordostschweizerische Kraftwerk AG
[3] KKG = Kernkraftwerk Gösgen-Däniken AG
[4] KKL = Kernkraftwerk Liebstadt AG
[5] BKW = Bernische Kraftwerk AG

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UNITED KINGDOM

The United Kingdom's (UK) 37 operating reactors achieved a 62 percent average net capacity factor in 1990 (**Table 29**). Nuclear power provided about 20 percent of the electricity generated in the UK in 1990. Three British reactors, Hunterston A-1 and A-2 (150-MWe Magnox units), and Winfrith (92-MWe steam generated heavy water reactor) were decommissioned during the year. The Dounreay liquid metal fast breeder reactor was decommissioned in early 1991.

The only nuclear unit under construction in the UK is the 1,100-MWe Sizewell B pressurized water reactor. The unit, nearly half complete, was eight months ahead of schedule as of the end of 1990. **Figure 22** is an aerial view of the Sizewell construction site.

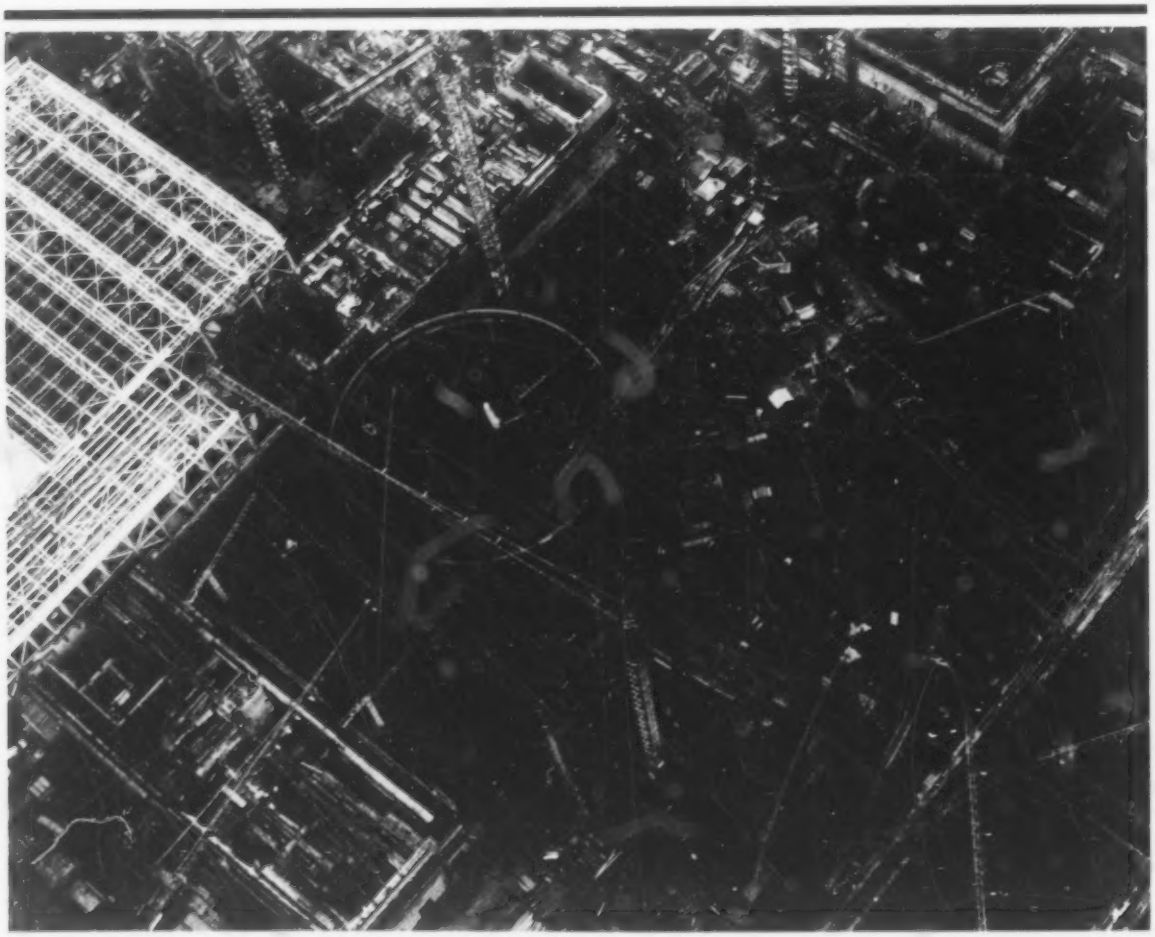

Figure 22 -- An aerial view at the construction site of the nearly half complete 1,100-MWe Sizewell B pressurized water reactor. *(Photo courtesy of Nuclear Electric.)*

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Figure 23
UNITED KINGDOM
NUCLEAR POWER UNITS AND FUEL CYCLE FACILITIES

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Table 29
NUCLEAR POWER STATIONS IN THE U.K.

Units/Stations In Operation

Unit/Station	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh Net)
Bradwell 1, 2	Nuclear Electric	123 ea.	GCR	1962	73	1,573
Calder Hall 1, 2, 3, 4	BNFL[2]	50 ea.	GCR	1956-59	88	1,525
Chapel Cross 1, 2, 3, 4	BNFL	48 ea.	GCR	1959-60	94	1,574
Dounreay	UKAEA[3]	234	LMFBR	1976	13	274
Dungeness A1, 2	Nuclear Electric	212 ea.	GCR	1965	75	2,784
Dungeness B1	Nuclear Electric	360	AGR	1985	28	874
Dungeness B2	Nuclear Electric	360	AGR	1989	26	825
Hartlepool A1	Nuclear Electric	420	AGR	1987	48	1,752
Hartlepool A2	Nuclear Electric	420	AGR	1987	91	3,342
Heysham A1	Nuclear Electric	470	AGR	1987	45	1,836
Heysham A2	Nuclear Electric	420	AGR	1987	86	3,146
Heysham B1	Nuclear Electric	615	AGR	1988	29	1,556
Heysham B2	Nuclear Electric	615	AGR	1989	15	798
Hinkley Point 1, 2	Nuclear Electric	235 ea.	GCR	1965	68	2,806
Hinkley Point B1	Nuclear Electric	560	AGR	1978	64	3,164
Hinkley Point B2	Nuclear Electric	560	AGR	1976	93	4,568
Hunterston A1, 2	Scottish Nuclear Ltd.	150 ea.	GCR	1964	74	2,324
Hunterston B1	Scottish Nuclear Ltd.	575	AGR	1976	96	4,861
Hunterston B2	Scottish Nuclear Ltd.	575	AGR	1977	65	3,283
Oldbury 1, 2	Nuclear Electric	217 ea.	GCR	1967-68	70	2,680
Sizewell A1, 2	Nuclear Electric	210 ea.	GCR	1966	78	2,877
Torness Point 1	Scottish Nuclear Ltd.	625	AGR	1988	36	1,997
Torness Point 2	Scottish Nuclear Ltd.	625	AGR	1989	—	2,003
Trawsfynydd 1, 2	Nuclear Electric	195 ea.	GCR	1965	81	2,773
Winfrith	UKAEA	92	HWLWR	1968	52	458
Wylfa 1, 2	Nuclear Electric	420 ea.	GCR	1971-72	96	7,093
TOTAL		**11,442**		***(1990 Average:***	**62)[4]**	**62,746**

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	Percent Complete[5]
Sizewell B1	Nuclear Electric	1,100	PWR	1994	50

[1] COD = Commercial Operation Date (actual or expected)
[2] BNFL = British Nuclear Fuels plc.
[3] UKAEA = United Kingdom Atomic Energy Authority
[4] Average does not include those units which entered commercial operation or were retired during 1990.
[5] Source: *Nuclear News*

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The UK utilities have continued to improve the performance of their Advanced Gas-Cooled Reactors (AGR). Scottish Nuclear's Hunterson B-1 became the first AGR to reach the 50 billion KWh (gross) milestone, which it passed in November 1990 and Nuclear Electric's AGRs set weekly power production records in January 1991.

The twelve regional electric companies in England and Wales were privatized during 1990. Investor enthusiasm was very strong, with subscription prices quickly bid to a substantial premium. The two conventional power generating operations in England and Wales, National Power and PowerGen, were privatized in early 1991, also with a warm reception from investors. The two Scottish conventional power generating companies, Hydro Electric and Scottish Power, are scheduled for privatization later in 1991. Nuclear Electric plc, which owns and operates the nuclear plants in England and Wales, and Scottish Nuclear Ltd, which owns and operates the Hunterston and Torness Point stations in Scotland, will both remain public-sector companies for the foreseeable future.

During the fall of 1990, Nuclear Electric announced its reorganization plans for the 1990s, aimed to make the utility more commercial. The three main facets of the strategy call for contracting non-core business services to outside companies; giving higher levels of responsibility to individual power stations and management units so as eventually to have them become profit centers; and introducing contractual relationships between different service groups within the company.

The UK utilities have uranium interests worldwide through various subsidiaries, including properties in Canada, Australia, and the USA. They purchase most fuel cycle services, including conversion, enrichment, fuel fabrication and reprocessing, from British Nuclear Fuels plc (BNFL), a government corporation. BNFL owns one-third of Urenco and operates Urenco's enrichment plant at Capenhurst, UK.

During 1990, BNFL signed several contracts for reprocessing with German utilities. The reprocessing will be performed in the Thermal Oxide Reprocessing Plant (THORP) currently under construction at Sellafield. **Figure 24** is an interior view of the THORP receiving and storage facility. THORP, and its associated waste management plants, will be phased into operation over the next 18 months. Also during 1990, BNFL began construction of an oxide fuel fabrication facility that will provide both light water reactor and AGR fuel, including the first core for Sizewell B.

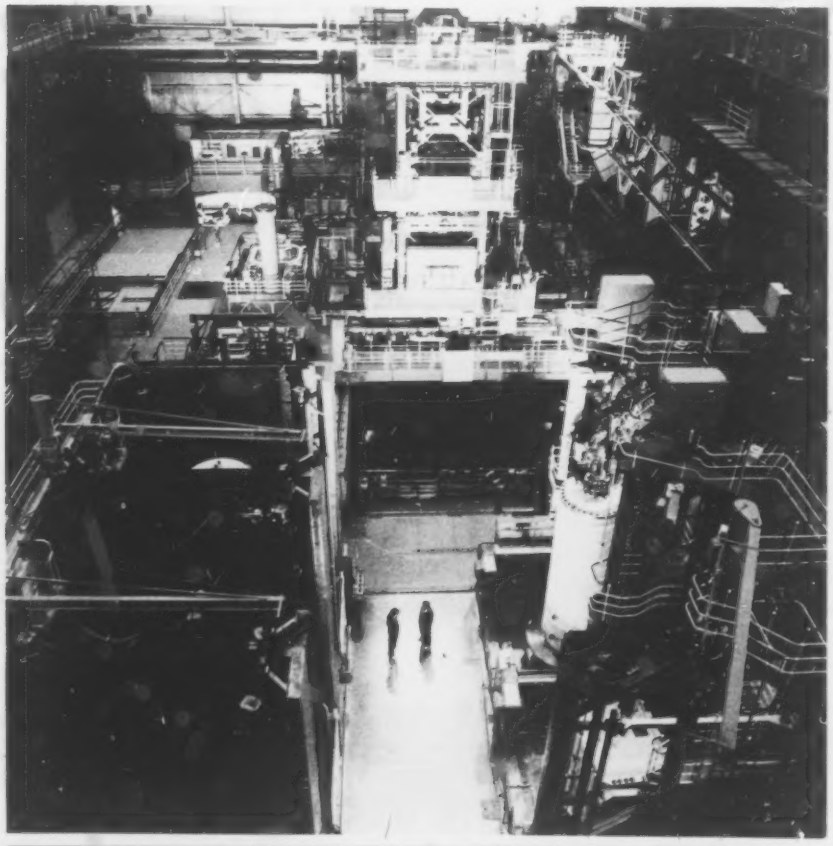

Figure 24 — The receiving and storage facility at the Thermal Oxide Reprocessing Plant, currently under construction at Sellafield. *(Photo courtesy of BNFL.)*

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YUGOSLAVIA

Yugoslavia's Krsko unit operated with a capacity factor of 81 percent during 1990. The unit, a 632-MWe Westinghouse pressurized water reactor (**Figure 25**), entered commercial operation in November 1983 and provides approximately five percent of Yugoslavia's electrical production. With its location near the border between Croatia and Slovenia, it is subject to the policies and politics of both republics. Due to the effectiveness of the anti-nuclear Green movement, the government in Slovenia announced its intention in 1990 to close down Krsko by 1995, and plans to hold a referendum on the issue. Krsko supplies about 17 percent of Slovenia's electricity. Croatia relies on Krsko for about 20 percent of its electricity and is opposed to shutting down the unit. The utility consortium operating the plant, Nuklearna Elektrarna Krsko (NEK), continues to upgrade the reactor, and, as an associate member of INPO, is working to meet that organization's performance indicator targets.

Production at Yugoslavia's Ruzv uranium mine, located in Slovenia, was halted in October 1990. The government of the republic of Slovenia officially closed the mine and mill in December, following an environmental review and publication of an unfavorable economic feasibility study. NEK entered a long-term supply contract for concentrates in 1990 to replace the loss of domestic production. The utility buys its enrichment needs from DOE, and Westinghouse makes the fuel. All spent fuel is stored on-site.

Figure 25—Krsko, a 632-MWe Westinghouse pressurized water reactor, entered commercial operation in November 1983 and provides approximately five percent of Yugoslavia's electrical production. (*Photo courtesy of NEK.*)

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NORTH AMERICA

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CANADA

URANIUM PRODUCTION

Canada maintained its position as the world's preeminent uranium producer during 1990. Uranium output from mines in Ontario and Saskatchewan totalled 22 million pounds U_3O_8, representing nearly 30 percent of Western World production.

Canadian uranium production declined by 25 percent from its 1989 level of 29.4 million pounds U_3O_8 (**Table 30**). This decrease reflected the severe downturn in Elliot Lake uranium activities, coupled with the shutdown of the Rabbit Lake mill for the entire year. Key Lake and Cluff Lake operations maintained a relatively stable production rate.

Elliot Lake, Ontario

Elliot Lake mines produced approximately 8.0 million pounds U_3O_8, a decrease of 21 percent from 1989. Output levels reflected the cutbacks and shutdowns of relatively high-cost production from these low-grade ore deposits. As older sales agreements either expire or undergo renegotiation, Elliot Lake operations are being rationalized.

Rio Algom Ltd. produced 4.4 million pounds U_3O_8 from its three Elliot Lake operations. This output level is a 22 percent decrease from 1989's level. The company announced in July that operations at its Quirke and Panel projects would be terminated by August, resulting in the loss of 1,700 jobs; C$125 million was allocated for these closures. This announcement represented an earlier closure date than was anticipated in 1989, when it was felt the Quirke and Panel production complexes would operate into early 1991. The resultant reduction in uranium output is more in line with Rio Algom's renegotiated long-term sales agreements involving US and European utilities. Under those contracts, all deliveries will now be completed by the end of 1992. Rio Algom will focus its attention upon the Stanleigh mine and mill operation, which will match its production to deliveries under the long-term sales agreement with Ontario Hydro.

Table 30
CANADAN URANIUM PRODUCTION (1986-1990)

Mine	Ownership	Production (Thousand Pounds Equivalent U_3O_8) 1986	1987	1988	1989	1990	1990 Relative To 1989
ONTARIO							
Elliot Lake	Denison Mines Ltd.	5,239	4,703	5,054	4,446	3,581	-19.5%
Panel	Rio Algom Ltd.	2,303	2,145	1,999	1,700	1,200	-29.4%
Quirke	Rio Algom Ltd.	3,273	2,896	2,891	2,750	2,000	-27.3%
Stanleigh	Rio Algom Ltd.	1,737	1,219	1,217	1,200	1,200	0%
SASKATCHEWAN							
Cluff Lake	Amok Ltd. (80%) Cameco (20%)	2,167	2,154	2,235	1,890	2,005	+6.1%
Key Lake	Cameco (66.7%) Uranerz (33.3%)	12,586	13,517	12,033	12,720	12,935	+1.7%
Rabbit Lake/Collins Bay	Cameco (66.7%) Uranerz (33.3%)	3,190	5,709	6,965	4,670	0	-100.0%
TOTAL		**30,495**	**32,343**	**32,394**	**29,376**	**22,921**	**-22.0%**

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Denison Mines Ltd. reduced its output by over 18 percent (3.6 million pounds U_3O_8), compared to the previous year's level of 4.4 million pounds U_3O_8. The company announced in March 1990 that annual production levels at its Elliot Lake facility would be decreased from 1989 levels, down to 2.7 million pounds U_3O_8 by August, resulting in an employment decline of 450 positions.

In March 1991, Denison Mines announced another reduction that will affect an additional 400 jobs and bring annual production rates down to 1.4 million pounds U_3O_8. This output will be delivered to Ontario Hydro under the existing long-term sales agreement. That agreement is being renegotiated with the outcome quite uncertain. One potential alternative for the utility would be to terminate further deliveries after 1992.

Saskatchewan

Uranium production in the province of Saskatchewan fell by 4.3 million pounds U_3O_8 from 1989 levels, a reduction of more than 22 percent. While production at Key Lake and Cluff Lake exhibited slight increases, the decision by Cameco to maintain the Rabbit Lake mill on stand-by status resulted in the production decline.

Cameco Corporation continued to operate the Key Lake mill (**Figure 26**) at slightly more than nameplate capacity, producing 12.9 million pounds U_3O_8 during the year. Principal mill feed was extracted from the Deilmann open pit, which is expected to provide ore to the Key Lake mill through the end of the decade, when the McArthur River deposit is scheduled for development.

The Rabbit Lake mill was shut down for mill modifications as of July 1, 1989. The modifications, now complete, consisted of solvent extraction circuit upgrades that will enable the facility to produce at an annual rate of 12.0 million pounds U_3O_8. The mill remained on stand-by throughout 1990 with restart anticipated in late 1991, depending upon market conditions, and full production, by 1996.

On July 25, 1990, Cameco completed the sale of a one-third interest in the Rabbit Lake mill, and the Collins Bay and Eagle Point South deposits, to Uranerz Exploration & Mining (UEM). UEM paid C$160 million for the minority-share position. This transaction resulted in a mining development change. Cameco now plans to develop the Eagle Point North and South deposits as a single underground mine, due to the commonality of ownership shares (previously, UEM owned only a one-third share of the Eagle Point North deposit). Site preparation began in 1990 and the construction of a decline into the deposit is scheduled for the spring of 1991. Production from the Eagle mine is planned for 1993. The Eagle deposit consists of 120 million pounds U_3O_8 at an average ore grade of 1.0 % U_3O_8.

On October 11, 1990, the Atomic Energy Control Board (AECB) renewed the operating license for Rabbit Lake, allowing the project to operate until October 1992 at a production rate of 12 million pounds U_3O_8 per year. At the same time, the AECB issued a statement that all new uranium mines will be subject to review by a Federal Environmental Assessment Review Office (FEARO) panel.

Cluff Lake (operated by Cluff Mining, which is owned 80 percent by AMOK and 20 percent by Cameco) operated at nominal capacity during the year (2.3 million pounds U_3O_8).

Figure 26 — Mill terrace at Cameco's Key Lake Project.
(Photo courtesy of Cameco.)

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The Cluff Lake mill was shut down temporarily in October 1989 while production from the Dominique-Peter underground mine was suspended. Operations resumed in early 1990 incorporating ore production from the Dominique-Janine North open-pit mine.

Exploration and Development Projects

Exploration activities in the Athabasca Basin of northern Saskatchewan remained the focal point of Canadian uranium exploration. Exploration expenditures during 1989 (most recent statistics available) remained relatively stable at C$58 million, compared to the 1988 level of C$59 million (**Table 31**).

According to the latest government estimates released in September, total recoverable, known uranium resources approximated 1.5 billion pounds equivalent U_3O_8 as of January 1, 1990, up by more than seven percent from the previous year's estimate of 1.4 billion pounds (**Table 32**).

Cigar Lake Mining Corporation (CLMC) (**Table 33**) remained on schedule and within budget during the year. After receiving approval for test mining in October 1987 from Saskatchewan Environment and Public Safety, a test shaft was started in 1988 and reached a depth of 500 meters by July 1990. Access drifts will be developed above and below the ore body to allow for on-going equipment tests as input to the project feasibility study. CLMC plans to conduct test mining during the middle of 1991 in order to determine the feasibility of several mining techniques.

The Midwest Joint Venture continued to conduct evaluations of its proposed development project. A project feasibility study has been completed and is undergoing internal review. In addition, an environmental impact statement has been prepared and submitted to appropriate federal and provincial agencies. The project's operator, Denison Mines Ltd., has submitted its initial filing with the AECB for environmental hearings.

Table 31
URANIUM EXPLORATION ACTIVITY IN CANADA 1980–1989

Year	Total Spent ($C Million)	Total Drilled (km)	Million Dollar Projects
1980	128	503	24
1982	71	247	13
1984	35	197	12
1986	33	162	11
1988	59	202	11
1989	58	158	11

Source: Energy, Mines and Resources Canada

Table 32
ESTIMATES OF KNOWN CANADIAN URANIUM RESOURCES
(Million Pounds Equivalent U_3O_8)

Principal Resource Categories	Recoverable Known Resources as of January 1, 1989	Recoverable Known Resources as of January 1, 1990
Measured	168.9	179.3
Indicated	582.2	553.6
Inferred	662.8	782.3
TOTAL	1,413.9	1,515.2

Source: Energy, Mines and Resources Canada

The proposed Kiggavik Project (Northwest Territories) appeared to have suffered a set-back during the year. An environmental assessment of the project was filed in late January 1990 with the FEARO panel, which identified several deficiencies in the Environmental Assessment Report. As a result, on July 5, 1990, Urangesellschaft Canada Ltd., the project's majority owner and operator, requested that the FEARO panel delay indefinitely its planned public hearing on the environmental assessment. This delay was requested in order to allow Urangesellschaft to conduct more thorough research and field work and prepare additional documentation. Urangesellschaft also must submit all documentation to the FEARO Panel "in layperson's language", written both in English and in Inuktitut (the language of the Inuit natives). These hearings have not yet been rescheduled. Moreover, an agreement-in-principle between the federal government, the government of the Northwest Territories, and the Tungavik Federation of Nunavut, regarding the Inuit land claim requires further clarification as to the claims' potential impact on the Kiggavik Project.

On May 30, 1990, Cameco announced another major uranium deposit discovery in northern Saskatchewan. The McArthur River deposit is located approx-

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imately 40 miles northeast of the Key Lake Project. Cameco is the largest share holder (43.9 percent), with Uranerz Exploration & Mining owning 29.4 percent. Initial indications placed the reserves at more than 100 million pounds U_3O_8; however, by the end of the year, that estimate had been increased to 200 million pounds U_3O_8 at an average grade of 4.0 %/o U_3O_8. The ore body is relatively deep (500-550 meters), and the geology is complex. Cameco management envisions this deposit providing feed to the Key Lake mill sometime in the late-1990s, or soon after the turn of the century, as current Key Lake sources are depleted.

On November 7, 1990, Minatco Ltd., an affiliate of

Table 33
UNDEVELOPED CANADIAN URANIUM DEPOSITS
(Scheduled for production before 2000)

Deposit	Location	Ownership	Reserves (Million Pounds Equivalent U_3O_8)
McArthur River	Saskatchewan	Cameco (44.0%) Uranerz (29.4%) AGIP Resources Ltd. (10.0%) Interuranium Canada Ltd. (9.1%) Cogema Canada Ltd. (6.5%) Imperial Metals Corp. (1.0%)	200
Cigar Lake	Saskatchewan	Cameco (48.75%) Cogema (36.375%) Idemitsu Kosan (12.875%) KEPCO[1] (2.00%)	385
Dawn Lake	Saskatchewan	Cameco (50.486%) Cogema (19.525%) PNC[2] (17.989%) PRI[3] (7.5%) KEPCO (4.5%)	30
Wooly (McClean Lake)	Saskatchewan	Minatco[4] (100.0%)	25-50
Midwest	Saskatchewan	Denison (45.0%) Bow Valley (20.0%) Uranerz (20.0%) OURD[5] (15.0%)	56

[1] KEPCO = Korea Electric Power Corporation. KEPCO purchased a two-percent non-voting interest in Cigar Lake.
[2] PNC = PNC (Exploration) Canada Limited, a wholly-owned subsidiary of Power Reactor and Nuclear Fuel Development Corporation (Japan).
[3] PRI = Power Resources Inc., a wholly-owned subsidiary of Nuclear Electric (United Kingdom).
[4] Minatco = Minatco Limited, a wholly-owned subsidiary of Total Compagnie Minière (France).
[5] OURD = Overseas Uranium Resources Development Company Ltd. of Japan.

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Total Compagnie Française des Petroles, announced that the company had increased its ownership share from 33.3 percent, to 100 percent in the Wolly Joint Venture (McClean) in northern Saskatchewan. This exploration project initially reported a reserve base of 14 million pounds U_3O_8 at an average grade of 1.75 % U_3O_8. Subsequent exploration activities in the area have resulted in a marked increase in that estimate, which now exceeds 50 million pounds U_3O_8.

Saskatchewan Uranium Royalty System

The province of Saskatchewan announced a revision to its uranium royalty system in July 1990. This new system, which is retroactive to July 1, 1989, consists of two tiers: a flat *ad valorem* royalty of 5 percent of gross sales, that may be used as a credit against the profit-related royalties; and a graduated scale of profit-related royalties levied against the profit per kilogram of annual uranium production.

The latter provision allows for graduated increases in the royalty rate (as a percent of profit), from zero percent when profits are less than C$2.00 per kilogram, to as much as 50 percent when the profit margin exceeds C$50.00 per kilogram produced.

URANIUM ENRICHMENT JOINT-VENTURE

On August 20, 1990, US-based Isotope Technologies, Inc. (ITI) announced the formation of a joint-venture with Cameco Corporation and Agra Industries, Ltd., both of Saskatoon, Saskatchewan. The newly formed entity, CRISLA Technologies, based in Saskatoon, will focus on the commercial development of the ITI-developed chemical reaction by isotope selective laser activation (CRISLA) technology for uranium enrichment.

CANADIAN URANIUM EXPORT POLICY

The Minister of Energy, Mines and Resources, the Honorable Jake Epp, set forth the latest interpretation of Canada's uranium export policy on May 18, 1990. The primary issues addressed in his letter related to domestic security of supply, pricing requirements, and further processing (upgrading) requirements.

The federal government liberalized its policy regarding domestic uranium requirements. Based upon the latest estimate of uranium resources, it is abundantly clear that Canada's uranium resources far exceed anticipated domestic requirements, as well as contracted exports. Therefore, the government made the decision to relax the regulation placed upon the domestic utilities requiring them to demonstrate that they had long-term uranium purchase contracts in place for a specified time horizon. In addition, the federal government will now approve uranium export agreements for up to thirty years, rather than the previous limit of 15 years. The Uranium Exports Review Panel will continue to review uranium export agreements, while Energy, Mines and Resources-Canada will continue to monitor the uranium resource situation on an annual basis.

As pointed out in the Minister's letter, uranium export contract pricing provisions have been subject to federal government review since 1969. While the review requirement will be carried forward, the review criteria have been simplified. The pricing policy states that "the Canadian government will expect pricing terms in export contracts to provide for an equitable balance of benefits and risks, and to be generally not less favourable than those being obtained in the same time period by competing Canadian and international producers for contracts of similar duration. In the interests of promoting stable productivity and employment, each export contract should include mechanisms, such as escalating floor price provisions, which will help to reduce the impact of unexpected shifts in the market, and thereby contribute to a more predictable commercial environment for both the company and its employees." It would appear that the Canadian (soft) contract floor price will remain acceptable under this interpretation of the pricing policy.

The long-standing requirement that uranium be subject to further processing (upgrading) within Canada prior to export created a complex regulatory situation, due to ever-increasing exemptions to that policy. Following implementation of the US-Canada Free Trade Agreement, uranium exports to the United States were specifically exempt from the upgrading requirement. However, this policy required further interpretation as it became evident that specific cases required additional oversight.

The May 18, 1990 letter sets forth further processing requirements as follows. As a basic statement, Canadian uranium destined for use as enriched uranium fuel shall be upgraded to the maximum extent possible in Canada prior to export, assuming that Canadian conversion facilities have available capacity. Exemptions will be granted in those

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cases where the Canadian convertor is not the successful bidder for conversion services as a result of purely commercial considerations. Moreover, an exemption will be granted when the uranium "will be converted or enriched or consumed in the United States." This latter exemption now allows such customers as the Japanese utilities holding USDOE enrichment contracts, to seek an exemption to the upgrading policy.

Uranium exports will continue to require the necessary export license and export permit. These permits will be granted for uranium exports under contracts determined to be consistent with the federal government's export policy.

NUCLEAR POWER DEVELOPMENTS

Following a relatively optimistic 1989, the commercial nuclear power program suffered some setbacks during 1990. As was reported last year, Ontario Hydro released its latest electricity demand and supply plan, *Providing the Balance of Power—Ontario Hydro's Plan to Serve Customers' Electricity Needs*, which addresses the planning horizon through the year 2014. The preferred option (Case 15), envisions the construction of ten CANDU reactors (881 MWe each) at three stations by the year 2014.

Ontario's provincial electorate voted the left-wing, anti-nuclear New Democratic Party (NDP) into power in the September 6 election. In its policy statement opening the

Figure 27 — New Brunswick Electric Power Company's Point Lepreau 1 nuclear power plant. The 630-MWe HWR generated over 5.7 TWh with a capacity factor of 96 percent during 1990.
(Photo courtesy of New Brunswick Electric Power Company.)

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new legislature, the NDP government stated that Ontario Hydro's plan for new nuclear construction would be deferred for at least three years and likely would be terminated altogether. Scheduled hearings on the demand and supply plan could proceed before the Environmental Assessment Board, but the government would not be bound by the Board's findings. Moreover, the NDP suspended funding for advanced reactor designs.

The Saskatchewan NDP reiterated its anti-nuclear stance during its provincial convention. The party specifically stated that an NDP provincial government would not allow the development of the proposed 10-MWe Local Energy System (the SLOWPOKE reactor) for the University of Saskatchewan.

Ontario's NDP government did allow for the completion of the Darlington Generating Station, located near the town of Newcastle, east of Toronto. Darlington consists of four CANDU reactors totaling 3,524 MWe that are scheduled to enter commercial operation by the end of 1992. Darlington Unit 2 entered commercial operation during 1990, the first of the four units to be completed. The Darlington project received provincial approval in July 1977, with site preparation commencing in 1978.

Ontario Hydro's nuclear generation suffered during 1990 (**Table 34**). Electricity generation from its nuclear units declined by more than 11 percent for the year. Extended outages were experienced at several reactors: Pickering Unit 3 was down all year, and Unit 4 was down for most of the year, both for retubing; Bruce 1 and 2 had capacity factors of only 30 percent and 34 percent, respectively. On the positive side, New Brunswick Electric Power Company's Point Lepreau 1 unit (**Figure 27**) performed very well during the year, generating over 5.7 TWh with a capacity factor of 96 percent.

MEXICO

Mexico's first commercial nuclear power unit, Laguna Verde 1 (654-MWe boiling water reactor), reached 100-percent power for the first time on March 17, 1990. Comision Federal de Electricidad (CFE) began construction on the Laguna Verde 1 plant in 1973. Total costs exceeded $3.5 billion, with the plant first reaching criticality on November 8, 1988. The unit was connected to the power grid on April 13, 1989.

A replicate unit, Laguna Verde 2, is under construction and about 62 percent complete. The reactor is planned for commercial operation in 1994. The two reactors will account for about five percent of Mexico's installed capacity, and should provide seven to eight percent of the country's annual electrical generation once they both reach commercial operation.

Mexico has identified approximately 20 million pounds equivalent U_3O_8 of reasonably assured uranium resources, but has not developed the deposits.

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Table 34
NUCLEAR POWER UNITS IN CANADA

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD [1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh Net)
Bruce 1	Ontario Hydro	848	HWR	1977	30	2,263
Bruce 2	Ontario Hydro	848	HWR	1977	34	2,558
Bruce 3	Ontario Hydro	848	HWR	1978	73	5,399
Bruce 4	Ontario Hydro	848	HWR	1979	48	3,564
Bruce 5	Ontario Hydro	860	HWR	1985	74	5,556
Bruce 6	Ontario Hydro	837	HWR	1984	85	6,235
Bruce 7	Ontario Hydro	860	HWR	1986	89	6,694
Bruce 8	Ontario Hydro	837	HWR	1987	79	5,788
Darlington 2	Ontario Hydro	881	HWR	1990	—	1,183
Gentilly 2	Hydro Quebec	640	HWR	1983	74	4,133
Pickering 1	Ontario Hydro	515	HWR	1971	68	3,053
Pickering 2	Ontario Hydro	515	HWR	1971	65	2,937
Pickering 3	Ontario Hydro	515	HWR	1972	0	0
Pickering 4	Ontario Hydro	515	HWR	1973	24	1,080
Pickering 5	Ontario Hydro	516	HWR	1983	86	3,869
Pickering 6	Ontario Hydro	516	HWR	1984	76	3,455
Pickering 7	Ontario Hydro	516	HWR	1985	77	3,492
Pickering 8	Ontario Hydro	516	HWR	1986	67	3,013
Point Lepreau 1	New Brunswick EPC [2]	635	HWR	1983	97	5,377
TOTAL		**13,066**		*(1990 Average:*	**64)** [3]	**69,649**

Units Under Construction or Planned

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD [1]	Percent Complete [4]
Darlington 1	Ontario Hydro	881	HWR	1991	99
Darlington 3	Ontario Hydro	881	HWR	1992	84
Darlington 4	Ontario Hydro	881	HWR	1993	64
Point Lepreau 2	New Brunswick EPC [2]	900	HWR	Indefinite	0
TOTAL		**3,543**			

[1] COD = Commercial Operation Date (actual or expected)

[2] EPC = Electric Power Company

[3] Average does not include those units which entered commercial operation or were retired during 1990.

[4] Source: *Nuclear News*

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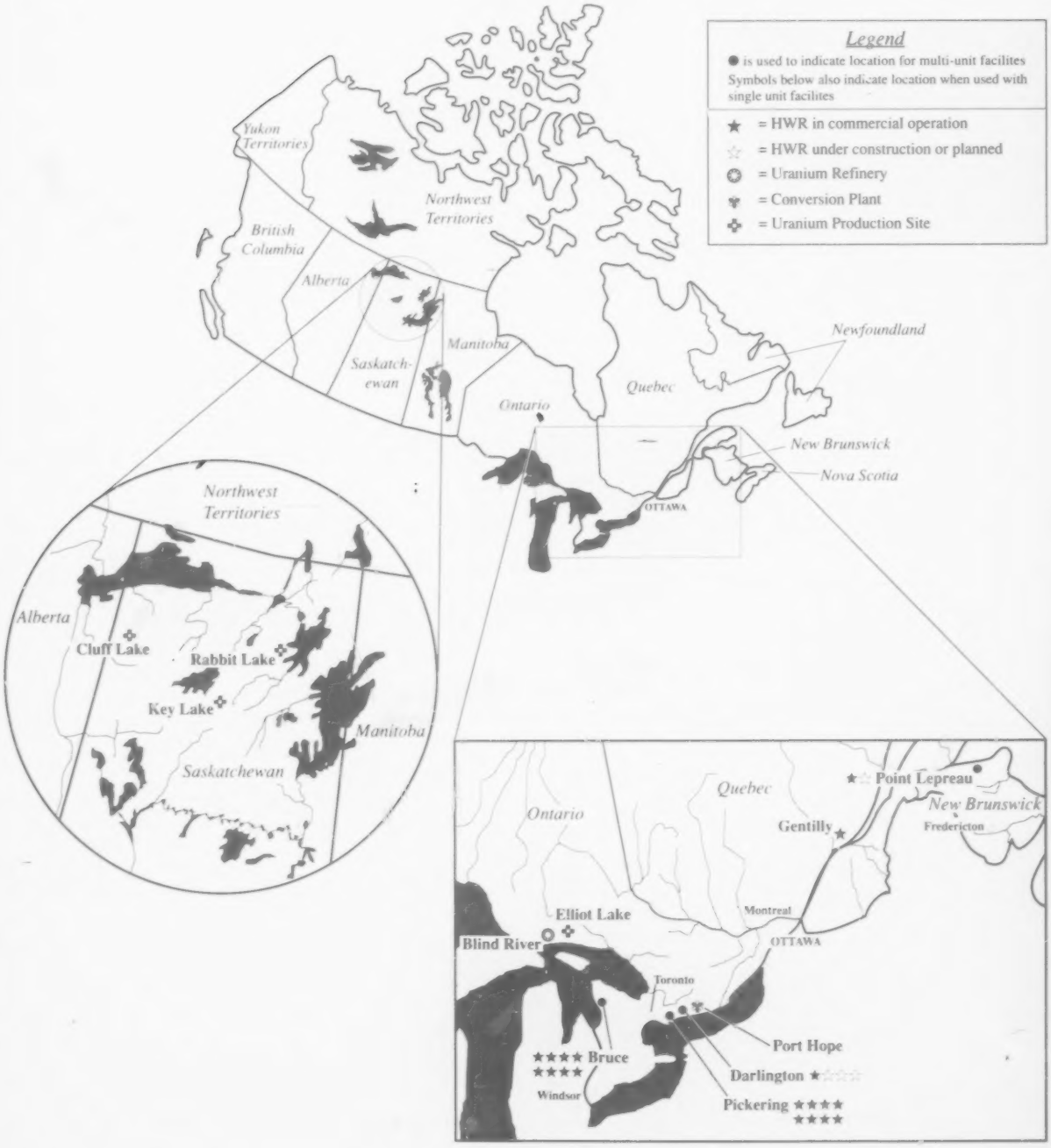
NORTH AMERICA

Figure 28
CANADA
NUCLEAR POWER UNITS AND URANIUM PRODUCTION AREAS



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UNITED STATES

OVERVIEW

As the US nuclear industry began the new decade, supporters hoped to see the start of a long-awaited recovery of the industry. Certain events during 1990 could signal the beginning of such a recovery:

- The backlog of nuclear plants under construction has declined to only two units: Tennessee Valley Authority's Watts Bar 1, and Texas Utilities' Comanche Peak 2. Both plants are projected to reach commercial operation by the end of 1992. This leaves seven units, in various stages of completion, categorized as indefinitely deferred, including the fully-completed Shoreham unit.
- Preliminary operation data illustrate that 1990 was a good year for nuclear power generation. Electrical output from nuclear plants during 1990 showed a nine-percent increase over 1989 results. The average US capacity factor increased from the 1989 level of 62 percent, to 67 percent in 1990.
- Work continues on a new generation of advanced light-water reactors. The new designs will incorporate improved passive safety features, and will be modular units that are slightly smaller and more cost-effective than the previous generation of plants. Progress in this area will enable utilities to place new plant orders later in the decade.
- President Bush's recently announced National Energy Strategy promotes nuclear power as a desirable alternative energy source to supply the country's future electricity needs. Media and public reaction to the nuclear goals of the plan have been generally subdued, indicating that public acceptance of nuclear power may be increasing through the "silent majority".
- While most high-cost uranium production centers have been shut down, and the nation's role as the world's largest uranium-producing country is clearly over for the foreseeable future, a smaller group of more efficient and flexible uranium production companies is emerging in the USA. As the industry has consolidated, much of it in the hands of non-US companies looking to expand their mining portfolios worldwide, the remaining producers have been forced to scale back operations, exploit only the most viable projects, and occasionally trade in the market to enhance their position. The industry continues to move toward lower-cost in-situ projects, and is likely to produce five to ten million pounds U_3O_8 per year through the end of the decade.

However, the US nuclear power industry still faces a number of obstacles. No new orders of nuclear plants by US utilities appear imminent, despite concerns over foreign oil dependence because of the Persian Gulf conflict. Concerns over global warming and the greenhouse effect resulted in minimal progress in public acceptability of nuclear power over the course of the past year. Finally, DOE and other governmental bodies made almost no progress in the important areas of enrichment restructuring and high-level waste disposal.

NUCLEAR POWER DEVELOPMENTS

Three units entered commercial operation during 1990: New Hampshire Yankee's Seabrook (**Figure 29**), a 1,150-MWe pressurized water reactor (PWR); Texas Utilities' Comanche Peak Unit 1, a 1,150-MWe PWR; and Philadelphia Electric Company's Limerick Unit 2, a 1,055-MWe boiling water reactor (BWR) (**Table 38**). This leaves only two units on the active backlog of plants under construction. Another seven units are indefinitely deferred, none of which is expected to operate in the foreseeable future (**Table 35**).

All three units entering service in 1990 had controversial construction histories. The long-delayed Seabrook plant withstood powerful opposition to the operation and emergency evacuation plans of the plant, eventually forcing the lead owner, Public Service of New Hampshire, into bankruptcy. Construction of the Limerick unit was suspended in 1982 by order of the Pennsylvania Public Utilities Commission because of cost overruns and concerns about the utility's financial health. Construction resumed

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in 1986, and the unit was completed ahead of schedule. Years of construction delays and intervention that affected the Comanche Peak plant were resolved in the last several years, and an innovative plan for oversight of the plant's operation is now in place.

In other developments, Oregon citizens voted on November 6, 1990 to keep Portland General Electric's Trojan nuclear plant in operation. The plant's fate has been subject to several public referenda over the last decade, each of which has affirmed the need for the plant's continued operation. The most recent measure sought to close the 1,095-MWe PWR until the federal government initiates construction of a spent fuel repository, an event that may take another 15 years or more to complete. One of the factors leading to the defeat of the referendum stemmed from the utility's estimates that replacement power for the Trojan plant would cost as much as $3 billion over a 20-year period.

Figure 29 — Seabrook Nuclear Power Plant, a 1,150-MWe PWR, that entered service in 1990.
(Photo courtesy of New Hampshire Yankee)

In 1990, there were further developments involving Long Island Lighting Company's (LILCO) Shoreham unit, the only fully operational nuclear plant in the USA to have been cancelled by public opposition before reaching full power. LILCO continues to dismantle parts of the unit so as to avoid potential problems with low-level waste disposal. However, LILCO's decommissioning efforts have been made more difficult by the fact that the state of New York has not yet met its schedule for development of a low-level waste disposal facility. The utility twice asked the Nuclear Regulatory Commission (NRC) to approve an amendment to the Shoreham operating license to allow LILCO to dispose of certain structural supports at the Barnwell, South Carolina, low-level waste facility. DOE objects to any removal of key structural parts because it is still promoting Shoreham's restart for energy security reasons.

Consumers Power Company, operator of the 730-MWe Palisades PWR, agreed in August to sell a 55-percent interest in the plant to Westinghouse Electric Company and Bechtel Power Company. The transaction is the culmination of more than three years of negotiation involving the unit, which has had a troubled operating history. The unit recently came back on-line after replacement of the steam generators. The three companies formed a partnership, Palisades Generating Company, to own and operate the plant as an independent power producer. Consumers will manage the plant and purchase its electrical output.

In November, Babcock & Wilcox and General Atomics formed a joint venture under the name of Triso to produce fuel and perform related services for modular high-temperature, gas-cooled reactors (HTGR). DOE's new production reactor program is expected to employ HTGR technology for some of its production.

In 1989, the NRC promulgated a new ruling designed to streamline reactor licensing. The ruling was immediately challenged by various groups. In December 1990, the US Court of Appeals for the DC Circuit upheld all but one aspect of the new rule. The court determined that the NRC could not limit intervenors to only one formal adjudicatory hearing

prior to construction. Nevertheless, the new rule, and the court decision supporting it, represents a positive step toward new reactor orders.

Uranium Contracting

US utilities accepted proposals and entered negotiations for 24 new long-term contracts during 1990. All but three of the contracts involved U_3O_8; the others involved UF_6. Estimates using nominal delivery quantities result in over 31 million pounds equivalent U_3O_8 scheduled for delivery during the period 1991-1997. As has been the trend in the USA, the majority of contracts (16) contained prices related to market-price indicators at the time of delivery, covering over 20 million pounds equivalent U_3O_8. However, seven contracts contained base-escalated or fixed prices. The base prices under base-escalated proposals continued to fall during 1990. This development induced certain utilities to take advantage of low market prices to hedge, at least for some of their requirements, against any significant market price rise in the future.

US companies acted as sellers in 14 of the contracts; the other sellers primarily were Canadian producers. In five instances, the seller was a non-North American company.

A comparison with 1989 long-term contracting data indicates that the number of contracts signed by US utilities more than doubled in 1990. However, total volume increased only by about 50 percent (31 million pounds U_3O_8, versus 21 million pounds in 1989), demonstrating that, on average, utilities are signing contracts for smaller total quantities.

Table 35
INCOMPLETE US NUCLEAR POWER UNITS

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	Percent Complete[1]	COD[2]
		Under Construction			
Comanche Peak 2	Texas Utilities Electric Co.	1,150	PWR	86	1992
Watts Bar 1	Tennessee Valley Authority	1,177	PWR	100	1992
TOTAL		**2,327**			
		Indefinitely Deferred			
Bellefonte 1	Tennesse Valley Authority	1,213	PWR	89	Indefinite
Bellefonte 2	Tennesse Valley Authority	1,213	PWR	58	Indefinite
Perry 2	CAPCO[3]	1,205	BWR	57	Indefinite
Shoreham	Long Island Lighting Co.	809	BWR	100	Indefinite
Watts Bar 2	Tennessee Valley Authority	1,177	PWR	85	Indefinite
WNP 1	WPPSS[4]	1,250	PWR	65	Indefinite
WNP 3	WPPSS	1,240	PWR	75	Indefinite
TOTAL		**9,357**			

[1] Source: Nuclear News
[2] COD = Commercial Operation Date (expected)
[3] CAPCO = Central Area Power Coordinating Group
[4] WPPSS = Washington Public Power Supply System

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LEGISLATIVE AND POLITICAL DEVELOPMENTS

Congress was active on energy issues in 1990, but its impact on the nuclear industry was limited. Congress enacted Clean Air legislation and a bill compensating uranium miners and downwinders who have developed cancer from radiation exposure. The US government renewed its efforts to restructure DOE's uranium enrichment program, but was unable to interest the relevant committees in the House of Representatives in the proposal, despite the release of a $2.5 million study referred to as the Smith-Barney report. That report recommends restructuring the program into a government corporation in order to be more competitive in the future. In 1990, DOE also devoted considerable attention to developing a National Energy Strategy. In November, the Nuclear Power Oversight Committee, composed of leaders from nuclear utilities, released their "Strategic Plan for Building New Nuclear Plants". The plan is the result of a year-long effort, and outlines a strategy to restore the nuclear option in the USA.

Uranium Enrichment

On May 18, 1990, DOE released an independent financial report, conducted by a team of consultants led by Smith Barney, Harris Upham & Company (Smith Barney), that recommended the eventual privatization of DOE's uranium enrichment enterprise (UEE). The nuclear industry and DOE wanted an independent study to prove to skeptics in Congress that UEE's problems are detrimental to its ability to compete, and harmful to US foreign policy and trade interests. The report found that DOE managers are constrained by pricing inflexibility, the federal government's short-term budget and planning process, conflicting congressional priorities, and a lack of coherent management structure.

In order to meet a perceived Congressional goal to maximize the money returned to the Treasury, Smith Barney recommended that rather than immediate privatization, a government corporation be created to ensure a smooth transition. Currently, a number of unknown liabilities and uncertainties about UEE's future competitiveness are affecting industry support for legislation:

1. Decommissioning and Decontamination (D & D) of the three existing gaseous diffusion plant (GDP) sites.
2. Environmental cleanup at the three sites.
3. Development and deployment costs of AVLIS.

The study recommends that once the corporation is removed from the government's annual appropriations process, it should set prices to recover costs for D&D, to deploy AVLIS, and to return money to the Treasury based on its ability to win market share.

To create a revenue stream for the Treasury to recover future costs, Smith Barney recommended that all past debt be forgiven. The accounting firm of Coopers and Lybrand (a member of the consulting team) conducted an analysis based on the Federal Energy Regulatory Commission's (FERC) rules on the recovery of costs for utilities. The consultants allocated some of the sunk costs into a category called "policy decisions"; that is, political decisions regarding projects such as the defunct Gaseous Centrifuge Enrichment Program (GCEP), the costs of which cannot be recovered from customers. The team then testified that rather than a debt, there actually is an over-recovery of approximately $1.2 billion. Smith Barney tried to make an irrefutable case that it did not matter what amount of debt was selected—if the number is too high, the corporation will not be competitive. Instead, the important issue is to create a competitive business that will return money to the Treasury. The report was intended to put to rest arguments about whether or not there is any unrecovered government investment. However, despite industry hopes for resolution of the issue, it is still one of the major problems in obtaining House concurrence on a bill.

Legislative Summary

While DOE and industry supporters' initial strategy was to increase interest, and thus improve the chances for action in Congress on a uranium enrichment restructuring bill, events did not turn out as planned. The Senate passed The Uranium Enrichment Restructuring Act (S 83) in 1989. Although the Senate held a number of hearings during 1990 on the Smith Barney report, and the House Science, Space and Technology subcommittee held several hearings on a counterpart bill (HR 2480), the other committees with jurisdiction (Energy and Commerce, and Interior and Insular Affairs) held only a joint hearing. Although the Smith Barney report was intended to generate interest in the House, the release of the report did not receive the Congressional attention necessary to generate action. Initially, DOE released only an executive summary. Several weeks later, it briefed members and committee staff, and provided copies of the full report. But by this time it was mid-summer, and the federal budget and Clean Air legislation took precedence on the Congressional agenda.

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Senator Wendell Ford (D-KY) and DOE did make one last attempt to enact uranium enrichment restructuring legislation last year. Since the House had failed to consider any bills, Sen. Ford amended S 83 to several bills Rep. Philip Sharp (D–IN) sponsored and passed from the House, in order to force discussion on uranium enrichment. Finally, S 83 was amended to a budget reconciliation bill in the closing days of the session. In order to have S 83 classified as relevant to budget reconciliation, the Congressional Budget Office (CBO) had to agree that the bill raised revenue. In order to win CBO support, the Senate made a proposal to raise about $100 million per year for five years, by requiring US utilities to pay .2 mil/kwh to fund D&D of the GDPs. While utilities are not opposed to funding D&D, they did object to a millage charge as the means of collecting the funds. Ultimately a compromise was not possible, and the amendment was removed from the budget bill. Since the 101st Congress ended its two-year session in December 1990, legislation must be reintroduced, and the entire process must begin again in 1991.

One positive outcome of Sen. Ford's effort to include S 83 on the budget reconciliation bill is that Rep. Sharp agreed that his committee would consider restructuring legislation early in 1991.

Clean Air Amendments Act

In December 1989, the EPA issued a proposed rule covering radionuclide emissions, which lowered permissible limits for uranium mining operations and nuclear power plants. The industry objected and initiated lobbying efforts in the EPA and Congress to remove the industry from the regulations, on the grounds that the industry is already adequately regulated by the NRC. In March 1990, the industry won a stay of implementation of a sub-section of the rule governing regulation of nuclear power plants, while the EPA considered industry's comments.

The industry then began lobbying Congress (as part of the discussion of the Clean Air bill), to have language added that would eliminate the dual regulation. Sen. Alan Simpson (R-WY) offered an amendment to the Clean Air Act Amendments bill that allows the EPA to defer to the NRC, if the EPA Administrator determines that the NRC's regulations "provide an ample margin of safety to protect the public health." Because of a heated debate over states' rights to enforce stricter standards under the Clean Air bill, the amendment also states "nothing in this subsection shall preclude or deny the right of any state or political subdivision thereof to adopt or enforce any standard which is more stringent."

The industry will now petition the EPA to be removed from EPA enforcement on the grounds that it is already adequately regulated by the NRC. The industry must then wait until the EPA makes a determination. Unfortunately, while that process takes place (there is no time limit set for the process), the uranium mining industry must meet both EPA and NRC regulatory standards.

The Clean Air Act will add $15-20 to the price of SWU beginning in 1995. The Act requires lower emissions from fossil power plants either as a result of installation of scrubbers or use of low-sulfur coal. The three plants that provide electricity for the GDPs are older coal-fired units and it will cost about $245 million per year to meet the new guidelines. The two utilities that operate the power plants for the GDPs, Ohio Valley Electric Corporation (OVEC) and Electric Energy Incorporated (EEInc), must meet the stricter SO_2 and NO_2 emissions restrictions by 1997 (assuming they choose to install scrubbers). The utilities can trade their emission credits, but it is not known whether they will successfully lower their cost and thus, electricity prices to DOE.

Other Legislative Activity

Louisiana Energy Services (LES) moved forward on its plans to build an enrichment plant in the USA. In order to facilitate licensing of the plant, LES requested a change in current NRC regulations from *10 CFR, Part 50* licensing, to *10 CFR, Parts 40 and 70*. Sen. J. Bennett Johnston (D-LA) sponsored the amendment in the Senate. After one hearing in the spring of 1990 and much backroom negotiation with the House Interior Committee, a compromise was reached. On the last day of the 101st Congress's session, the LES licensing amendment was passed as an amendment to HR 4808, which amended the Public Utilities Regulatory Policy Act (PURPA) to make it easier for wind, geothermal, and solar power producers to receive exemptions from PURPA.

Sen. Johnston was able to maintain the concept of one-step licensing as a materials handling license (as part of *10 CFR,*

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Parts 40 and 70). Thus, a hearing will be held and the operating license can be issued at its conclusion. Several additional requirements were stipulated as part of the negotiations between the House and Senate committees. The compromise involved assuring various environmental groups that public participation is built into the process. An environmental impact statement (EIS), as opposed to an environmental assessment is required. An EIS is more formal and legalistic, requires a public hearing, and usually takes about one year to complete. In addition, an adjudicatory hearing prior to construction must be held. The requirement of an adjudicatory hearing also makes the process more legalistic and creates the potential for additional delay on the part of intervenors. Enrichment plants are not included in Price-Anderson Act indemnification.

The President and Congress established diplomatic relations with Namibia and lifted all economic sanctions against the country when it became independent on March 21, 1990. Uranium from Namibia's Rössing project is now acceptable in the USA and throughout the world, as most other countries lifted sanctions as well.

In November 1990, Philip Bayne, President and Chief Operating Officer of New York Power Authority, announced the Nuclear Power Oversight Committee's (NPOC) strategic plan for building a new nuclear power plant. The study sets out a schedule with specific tasks for each industry association to accomplish in order to establish a framework so a new order can be placed by 1995, and construction completed by 2000. The primary goals are:

- Maintain records of safe operation at current plants.
- Make progress on siting an HLW repository, and MRS and LLW sites.
- Ensure a stable supply of uranium and uranium enrichment. (Support restructuring legislation.)
- Ensure a stable, predictable regulatory process for licensing.
  - —Ask for legislation to streamline licensing.
  - —Eliminate dual regulation.
  - —By 1992, obtain NRC approval of GE's ABW reactor design and ABB–CE's System 80+ design, and by 1995, approval of Westinghouse's AP600 and GE's simplified BWR designs.
- Implement standardization.
  - —Finish NRC-certified design of advanced reactors.
  - —Coordinate siting with design.
- Improve institutional support.
  - —Broaden public acceptance at national and local level.
  - —Create financing mechanisms.
  - —Support state regulatory reform.
  - —Enhance government support for new nuclear plants.

US URANIUM PRODUCTION

The US uranium industry suffered a further output reduction during 1990 (**Figure 30**). Uranium concentrates production totalled 10.2 million pounds U_3O_8, a decline of more than 26 percent from the 1989 production level of 13.8 million pounds U_3O_8 (**Table 36**). Mining from conventional and minewater sources accounted for 58 percent of the total while phosphate by-product facilities generated 28 percent. Solution mining produced 14 percent of the total.

Production declined across the board, with solution mining output down almost 38 percent (0.9 million pounds U_3O_8), conventional and minewater production declining by 28 percent (2.3 million pounds U_3O_8) and by-product output off by more than 22 percent (0.8 million pounds U_3O_8). 1990 US uranium production represented only 23 percent of its 1980 output of 43.7 million pounds U_3O_8.

Table 36

US URANIUM PRODUCTION BY TYPE

(Million Pounds Equivalent U_3O_8)

	1982	1983	1984	1985	1986	1987	1988	1989	1990
Conventional	20.6	14.8	9.5	5.4	9.0	8.2	7.4	8.2	5.9
By-Product	3.2	3.1	3.1	3.6	3.2	3.4	3.5	3.2	2.8
Solution Mining	3.0	2.8	2.1	2.1	0.9	0.7	2.5	2.4	1.5
TOTAL	**26.8**	**20.7**	**14.7**	**11.1**	**13.1**	**12.3**	**13.4**	**13.8**	**10.2**

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Energy Fuels was the largest US producer in 1990 (**Table 37**), producing an estimated 2.5 million pounds U_3O_8 from its high-grade breccia pipes in Arizona. However, the company reduced its mining activities to a single project (Kanab North) by the end of the year.

Uranium Resources, Inc. initiated commercial production at its Rosita Project (Duval County, Texas) in September. This solution mine produced about 250,000 pounds U_3O_8 during 1990, with final processing at the Kingsville Dome plant (the Kingsville mine is currently on stand-by, but the central processing plant is operating).

On April 24, 1990, Ferret Exploration of Nebraska, Inc. received the necessary permits to construct the Crow Butte Project. Project construction was initiated immediately with commercial production scheduled for April 199'. This solution mining project will be the first uranium production facility in the state of Nebraska.

Production facility closures continued as uranium mining companies reacted to persistently low spot market prices. Chevron Resources Company ceased production at its Mount Taylor Mine (New Mexico) on January 12, 1990. In mid-1990, the mine was allowed to flood and was permanently closed. During the month of October, Chevron requested offers for its remaining uranium assets including producing properties, ore stockpiles, reserves, U_3O_8 inventory, and long-term uranium sales agreements.

Figure 30
HISTORICAL US URANIUM PRODUCTION
1947–1990

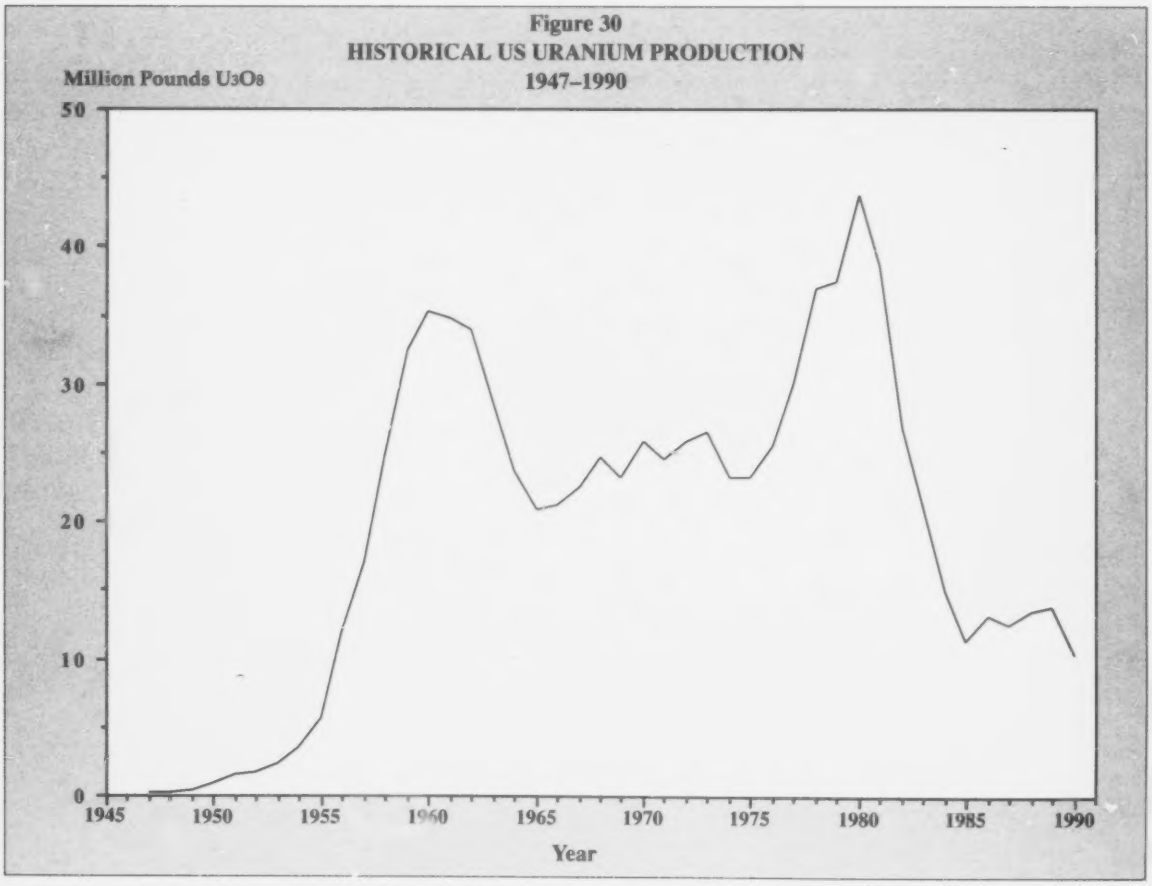

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Table 37
US URANIUM PRODUCTION FACILITIES

Production Center	Location	Principal Owner	Type	Annual Capacity (thousand pounds equivalent U_3O_8)
OPERATING[1]				
Rosita	Texas	URI	Solution	800
Highland	Wyoming	Power Resources	Solution	1,000
New Wales	Florida	IMC	By-product (P_2O_5)	1,200
Plant City	Florida	IMC	By-product (P_2O_5)	800
Uncle Sam	Louisiana	Freeport	By-product (P_2O_5)	750
Donaldsonville	Louisiana	Freeport	By-product (P_2O_5)	400
Ambrosia Lake	New Mexico	Rio Algom	By-product (minewater)	200
Grants	New Mexico	Homestake	By-product (minewater)	200
Panna Maria/Rhode Ranch	Texas	Chevron	Conventional	1,500
Shirley Basin	Wyoming	Pathfinder	Conventional	500
STANDBY[1]				
El Mesquite	Texas	Malapai	Solution	300
Hobson	Texas	Everest	Solution	150
Irigaray	Wyoming	Malapai	Solution	500
Kingsville Dome	Texas	URI	Solution	1,000
West Cole	Texas	Total	Solution	200
Bingham	Utah	Energy Fuels	By-product (Cu)	150
Calgary	Alberta, Canada	Earth Sciences	By-product (P_2O_5)	120
Grants	New Mexico	Homestake	Conventional	300
Mt. Taylor	New Mexico	Chevron	Conventional	1,600
White Mesa	Arizona/Utah	Energy Fuels	Conventional	3,200+
White Mesa	Colorado/Utah	Umetco	Conventional	500+
Canon City	Colorado	Cotter	Conventional	500
Gas Hills	Wyoming	Pathfinder	Conventional	500
Ambrosia Lake	New Mexico	Rio Algom	Conventional	2,500
Sherwood	Washington	Western Nuclear	Conventional	1,000
Sweetwater	Wyoming	Minerals Exploration	Conventional	1,000

[1] Status as of 12-31-90

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Umetco Minerals Corporation placed the White Mesa Mill (Blanding, Utah) on standby in October. The company then ceased mining activities at the La Sal, Sunday, and Dove Creek sites (Colorado Plateau) on November 8.

Non-US entities increased their ownership positions in US uranium production facilities and reserves. The countries represented in this activity included Taiwan, France, and the United Kingdom.

Pinnacle West Capital Corporation sold its interest in Malapai Resources Company (MRC) to a venture involving Fuel International Trading Corporation (FITCO), which is a subsidiary of Société Auxiliare d'Energie (SAE), itself a wholly-owned subsidiary of Electricité de France (EdF). The venture also involves Total Minerals Corporation which will operate the former MRC properties, including Irigaray/Christensen Ranch (Wyoming) and El Mesquite (Texas), all of which employ solution mining technology.

On March 22, 1990, US Energy Corp., its subsidiary Crested Corporation, and Kennecott Corporation entered into a restructured joint-venture agreement for the development of uranium properties. Kennecott is an equal partner with US Energy and Crested, having paid $15 million to enter into the joint venture, and committing an additional $50 million for property development. The joint venture plans to develop certain Wyoming properties, of which Green Mountain (Fremont County, Wyoming) is the project scheduled for initial development.

Freeport Uranium Recovery Company (FURC) entered into a joint-venture with Denison Mines, Ltd. for future production from FURC's phosphate by-product facilities. Denison provided the funding necessary to restart the by-product recovery circuit at the Sunshine Bridge (Donaldsonville), Louisiana plant.

IMC Fertilizer's uranium production (phosphate by-product) remained relatively stable during the year. Total production approximated 2.1 million pounds U_3O_8.

Figure 31 — The Rhode Ranch open pit mine in southern Texas is a joint-venture between Chevron and TOTAL Minerals. *(Photo courtesy of Chevron.)*

Table 38
NUCLEAR POWER UNITS IN THE USA

Units Licensed for Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh Net)
Arkansas 1	Entergy Operations	836	PWR	1974	57	4,183
Arkansas 2	Entergy Operations	858	PWR	1980	95	7,127
Arnold 1	Iowa Electric Light & Power Co.	538	BWR	1975	66	3,093
Beaver Valley 1	CAPCO[2]	810	PWR	1976	89	6,281
Beaver Valley 2	CAPCO	833	PWR	1987	60	4,374
Big Rock Point	Consumers Power Co.	67	BWR	1963	74	432
Braidwood 1	Commonwealth Edison Co.	1,120	PWR	1988	84	8,321
Braidwood 2	Commonwealth Edison Co.	1,120	PWR	1988	65	6,358
Browns Ferry 1	Tennessee Valley Authority	1,065	BWR	1974	0	0
Browns Ferry 2	Tennessee Valley Authority	1,065	BWR	1975	0	0
Browns Ferry 3	Tennessee Valley Authority	1,065	BWR	1977	0	0
Brunswick 1	Carolina Power & Light Co.	790	BWR	1977	62	4,297
Brunswick 2	Carolina Power & Light Co.	790	BWR	1975	59	4,051
Byron 1	Commonwealth Edison Co.	1,105	PWR	1985	73	7,021
Byron 2	Commonwealth Edison Co.	1,105	PWR	1987	63	6,118
Callaway	Union Electric Co.	1,118	PWR	1984	82	8,054
Calvert Cliffs 1	Baltimore Gas & Electric Co.	825	PWR	1975	19	1,351
Calvert Cliffs 2	Baltimore Gas & Electric Co.	825	PWR	1977	20	0
Catawba 1	Duke Power Co.	1,129	PWR	1985	71	6,997
Catawba 2	Duke Power Co.	1,129	PWR	1986	66	6,553
Clinton 1	Illinois Power Co.	946	BWR	1987	44	3,669
Comanche Peak 1	Texas Utilities Electric Co.	1,150	PWR	1990	—	3,525
Cook 1	American Electric Power Co.	1,020	PWR	1975	70	6,277
Cook 2	American Electric Power Co.	1,060	PWR	1978	51	4,776
Cooper	Nebraska Public Power District	764	BWR	1974	76	5,068
Crystal River 3	Florida Power Corp.	821	PWR	1977	58	4,173
Davis-Besse 1	CAPCO	860	PWR	1978	56	4,191
Diablo Canyon 1	Pacific Gas & Electric Co.	1,073	PWR	1985	93	8,773
Diablo Canyon 2	Pacific Gas & Electric Co.	1,087	PWR	1986	80	7,597

[1] COD = Commercial Operation Date

[2] CAPCO = Central Area Power Coordinating Group

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Table 38
NUCLEAR POWER UNITS IN THE USA
(Continued)

Units Licensed for Operation
(Continued)

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh Net)
Dresden 2	Commonwealth Edison Co.	772	BWR	1970	61	4,146
Dresden 3	Commonwealth Edison Co.	773	BWR	1971	76	5,160
Farley 1	Southern Company Services	824	PWR	1977	97	6,972
Farley 2	Southern Company Services	830	PWR	1981	73	5,301
Fermi 2	Detroit Edison Co.	1,093	BWR	1988	75	7,104
Fitzpatrick	New York Power Authority	757	BWR	1975	69	4,578
Fort Calhoun 1	Omaha Public Power District	478	PWR	1974	58	2,431
Ginna 1	Rochester Gas & Electric Corp.	470	PWR	1970	84	3,473
Grand Gulf 1	Entergy Operations	1,142	BWR	1985	74	7,438
Haddam Neck	Northeast Utilities	565	PWR	1968	24	1,196
Harris 1	Carolina Power & Light Co.	860	PWR	1987	86	6,509
Hatch 1	Southern Company Services	757	BWR	1975	62	4,119
Hatch 2	Southern Company Services	768	BWR	1979	97	6,556
Hope Creek 1	Public Service Electric & Gas	1,031	BWR	1986	90	8,135
Indian Point 2	Consolidated Edison Co. New York	864	PWR	1974	68	5,181
Indian Point 3	New York Power Authority	965	PWR	1976	59	4,990
Kewaunee	Wisconsin Public Service Corp.	503	PWR	1974	89	3,930
La Salle 1	Commonwealth Edison Co.	1,036	BWR	1984	95	8,586
La Salle 2	Commonwealth Edison Co.	1,036	BWR	1984	68	6,182
Limerick 1	Philadelphia Electric Co.	1,055	BWR	1986	61	5,631
Limerick 2	Philadelphia Electric Co.	1,055	BWR	1990	—	7,447
McGuire 1	Duke Power Co.	1,129	PWR	1981	48	4,780
McGuire 2	Duke Power Co.	1,129	PWR	1984	65	6,456
Millstone 1	Northeast Utilities	654	BWR	1971	89	5,121
Millstone 2	Northeast Utilities	863	PWR	1975	70	5,283
Millstone 3	Northeast Utilities	1,142	PWR	1986	83	8,255
Monticello	Northern States Power Co.	536	BWR	1971	96	4,513
Nine Mile Point 1	Niagara Mohawk Power Corp.	610	BWR	1969	24	1,278
Nine Mile Point 2	Niagara Mohawk Power Corp.	1,072	BWR	1988	45	4,246

[1] COD = Commercial Operation Date

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Table 38
NUCLEAR POWER UNITS IN THE USA
(Continued)

Units Licensed for Operation
(Continued)

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh Net)
North Anna 1	Virginia Electric Power Co.	915	PWR	1978	91	7,306
North Anna 2	Virginia Electric Power Co.	915	PWR	1980	75	6,026
Oconee 1	Duke Power Co.	846	PWR	1973	87	6,469
Oconee 2	Duke Power Co.	846	PWR	1974	85	6,277
Oconee 3	Duke Power Co.	846	PWR	1974	100	7,418
Oyster Creek 1	GPU Nuclear Corp.	620	BWR	1969	79	4,308
Palisades	Consumers Power Co.	730	PWR	1971	48	3,074
Palo Verde 1	Arizona Public Service Co.	1,221	PWR	1986	45	4,974
Palo Verde 2	Arizona Public Service Co.	1,221	PWR	1986	60	6,371
Palo Verde 3	Arizona Public Service Co.	1,221	PWR	1988	92	9,800
Peach Bottom 2	Philadelphia Electric Co.	1,051	BWR	1974	73	6,677
Peach Bottom 3	Philadelphia Electric Co.	1,035	BWR	1974	83	7,498
Perry 1	CAPCO[2]	1,141	BWR	1987	67	6,673
Pilgrim 1	Boston Edison Co.	670	BWR	1972	72	4,239
Point Beach 1	Wisconsin Electric Power Co.	485	PWR	1970	83	3,530
Point Beach 2	Wisconsin Electric Power Co.	485	PWR	1972	89	3,801
Prairie Island 1	Northern States Power Co.	503	PWR	1973	88	3,895
Prairie Island 2	Northern States Power Co.	500	PWR	1974	88	3,863
Quad Cities 1	Commonwealth Edison Co.	769	BWR	1973	79	5,326
Quad Cities 2	Commonwealth Edison Co.	769	BWR	1973	65	4,346
River Bend 1	Gulf States Utilities Co.	936	BWR	1986	70	5,743
Robinson 2	Carolina Power & Light Co.	665	PWR	1971	58	3,355
Salem 1	Public Service Electric & Gas	1,106	PWR	1977	62	5,983
Salem 2	Public Service Electric & Gas	1,106	PWR	1981	56	5,440
San Onofre 1	Southern California Edison Co.	436	PWR	1968	41	1,579
San Onofre 2	Southern California Edison Co.	1,070	PWR	1983	89	8,357
San Onofre 3	Southern California Edison Co.	1,080	PWR	1984	70	6,667
Seabrook	Yankee Atomic Group[3]	1,150	PWR	1990	—	4,114

[1] COD = Commercial Operation Date

[2] CAPCO = Central Area Power Coordinating Group

[3] Consists of Maine Yankee Atomic Power Company, Vermont Yankee Nuclear Power Corporation, Public Service Company of New Hampshire, and Yankee Atomic Electric Company.

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Table 38
NUCLEAR POWER UNITS IN THE USA
(Continued)

Units Licensed for Operation
(Continued)

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh Net)
Sequoyah 1	Tennesse Valley Authority	1,148	PWR	1981	68	6,792
Sequoyah 2	Tennesse Valley Authority	1,148	PWR	1982	71	7,146
South Texas 1	Houston Lighting & Power Co.	1,250	PWR	1988	56	6,093
South Texas 2	Houston Lighting & Power Co.	1,250	PWR	1989	60	6,517
St. Lucie 1	Florida Power & Light Co.	839	PWR	1976	62	4,561
St. Lucie 2	Florida Power & Light Co.	839	PWR	1983	74	5,402
Summer	South Carolina Electric & Gas	885	PWR	1984	79	6,120
Surry 1	Virginia Electric Power Co.	781	PWR	1972	70	4,815
Surry 2	Virginia Electric Power Co.	781	PWR	1973	86	5,885
Susquehanna 1	Pennsylvania Power & Light Co.	1,032	BWR	1983	71	6,435
Susquehanna 2	Pennsylvania Power & Light Co.	1,038	BWR	1985	91	8,226
Three Mile Island 1	GPU Nuclear Corp.	808	PWR	1974	76	5,411
Trojan	Portland General Electric Co.	1,095	PWR	1976	64	6,140
Turkey Point 3	Florida Power & Light Co.	666	PWR	1972	58	3,402
Turkey Point 4	Florida Power & Light Co.	666	PWR	1973	76	4,413
Vogtle 1	Southern Company Services	1,083	PWR	1987	78	7,410
Vogtle 2	Southern Company Services	1,083	PWR	1989	73	6,933
Waterford 3	Entergy Operations	1,075	PWR	1985	92	8,617
WNP 2	WPPSS[2]	1,095	BWR	1984	50	5,764
Wolf Creek	Kansas Gas & Electric Co.	1,135	PWR	1985	79	7,882
Yankee Maine	Yankee Atomic Group[3]	810	PWR	1972	68	4,803
Yankee Rowe	Yankee Atomic Group	167	PWR	1961	58	848
Yankee Vermont	Yankee Atomic Group	504	BWR	1972	83	3,646
Zion 1	Commonwealth Edison Co.	1,040	PWR	1973	51	4,616
Zion 2	Commonwealth Edison Co.	1,040	PWR	1974	30	2,692
TOTAL		**99,299**		*(1990 Average:*	**67)**[4]	**581,335**

[1] COD = Commercial Operation Date

[2] Washington Public Power Supply System

[3] Consists of Maine Yankee Atomic Power Company, Vermont Yankee Nuclear Power Corporation, Public Service Company of New Hampshire, and Yankee Atomic Electric Company.

[4] Average does not include those units which entered commercial operation or were retired during 1990.

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INDEX TO FIGURE 32
LICENSED NUCLEAR POWER STATIONS IN THE USA

FUEL BUYER	STATION	
1 - Yankee Atomic Group[1]	Yankee Maine	■
2 - Yankee Atomic Group[1]	Seabrook	■
3 - Yankee Atomic Group[1]	Yankee Vermont	▲
4 - Yankee Atomic Group[1]	Yankee Rowe	■
5 - Yankee Atomic Group[1]	Haddam Neck	■
6 - Boston Edison Co.	Pilgrim	▲
7 - Northeast Utilities	Millstone	▲■■
8 - Long Island Lighting Co.	Shoreham	
9 - Consolidated Edison Co. New York	Indian Point 2	■
New York Power Authority	Indian Point 3	■
10 - New York Power Authority	Fitzpatrick	▲
11 - Niagara Mohawk Power Corp.	Nine Mile Point	▲▲
12 - Rochester Gas and Electric Corp.	Ginna	■
13 - Pennsylvania Power and Light Co.	Susquehanna	▲▲
14 - Philadelphia Electric Co.	Limerick	▲▲
15 - Philadelphia Electric Co.	Peach Bottom	▲▲
16 - GPU Nuclear Corp.	Three Mile Island	■
17 - GPU Nuclear Corp.	Oyster Creek	▲
18 - Public Service Electric & Gas	Salem	■■
19 - Public Service Electric & Gas	Hope Creek	▲
20 - Baltimore Gas & Electric Co.	Calvert Cliffs	■■
21 - Virginia Electric Power Co.	North Anna	■■
22 - Virginia Electric Power Co.	Surry	■■
23 - Carolina Power & Light Co.	Harris	■
24 - Carolina Power & Light Co.	Brunswick	▲▲
25 - Carolina Power & Light Co.	Robinson	■
26 - Duke Power Co.	McGuire	■■
27 - Duke Power Co.	Catawba	■■
28 - Duke Power Co.	Oconee	■■■
29 - South Carolina Electric & Gas	Summer	■
30 - Tennessee Valley Authority	Sequoyah	■■
31 - Tennessee Valley Authority	Watts Bar	
32 - Tennessee Valley Authority	Bellefonte	
33 - Tennessee Valley Authority	Browns Ferry	▲▲▲
34 - Southern Company Services	Vogtle	■■
35 - Southern Company Services	Hatch	▲▲
36 - Southern Company Services	Farley	■■
37 - Florida Power Corp.	Crystal River	■

FUEL BUYER	STATION	
38 - Florida Power & Light Co.	St. Lucie	■■
39 - Florida Power & Light Co.	Turkey Point	■■
40 - Gulf States Utilities Co.	River Bend	▲
41 - Entergy Operations	Waterford	■
42 - Entergy Operations	Grand Gulf	▲
43 - Entergy Operations	Arkansas	■■
44 - Union Electric Co.	Callaway	■
45 - Illinois Power Co.	Clinton	▲
46 - Commonwealth Edison Co.	Quad Cities	▲▲
47 - Commonwealth Edison Co.	Byron	■■
48 - Commonwealth Edison Co.	La Salle	▲▲
49 - Commonwealth Edison Co.	Dresden	▲▲
50 - Commonwealth Edison Co.	Zion	■■
51 - Commonwealth Edison Co.	Braidwood	■■
52 - CAPCO[2]	Davis-Besse	■
53 - CAPCO[2]	Beaver Valley	■■
54 - CAPCO[2]	Perry	▲△
55 - Detroit Edison Co.	Fermi	▲
56 - American Electric Power Co.	Cook	■■
57 - Consumers Power Co.	Palisades	■
58 - Consumers Power Co.	Big Rock Point	▲
59 - Wisconsin Public Service Corp.	Kewaunee	■
60 - Wisconsin Electric Power Co.	Point Beach	■■
61 - Northern States Power Co.	Monticello	▲
62 - Northern States Power Co.	Prairie Island	■■
63 - Iowa Electric Light & Power Co.	Arnold	▲
64 - Omaha Public Power District	Fort Calhoun	■
65 - Nebraska Public Power District	Cooper	▲
66 - Kansas Gas & Electric Co.	Wolf Creek	■
67 - Texas Utilities Electric Co.	Comanche Peak	■□
68 - Houston Lighting & Power Co.	South Texas	■■
69 - Arizona Public Service Co.	Palo Verde	■■■
70 - Southern California Edison Co.	San Onofre	■■■
71 - Pacific Gas & Electric Co.	Diablo Canyon	■■
72 - Portland General Electric Co.	Trojan	■
73 - WPPSS[3]	WNP 1 & 2	□▲
74 - WPPSS[3]	WNP 3	□

[1] Yankee Atomic Group consists of Maine Yankee Atomic Power Company, Vermont Yankee Nuclear Power Corporation, Public Service Company of New Hampshire, and Yankee Atomic Electric Company.

[2] CAPCO = Central Area Power Coordinating Group

[3] WPPSS = Washington Public Power Supply System

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Figure 32
US LICENSED NUCLEAR POWER STATIONS AND FUEL CYCLE FACILITIES

Legend
Number or symbol indicates location
■ = PWR in commercial operation
□ = PWR under construction or planned
▲ = BWR in commercial operation
△ = BWR under construction or planned
✤ = Uranium Production (conventional)
⁜ = Uranium Production (solution or by-product)
✾ = Conversion Plant
➡ = Enrichment Plant

FUEL CYCLE FACILITIES		
Key	**Company**	**Location**
A ✤	= Pathfinder Mines	Shirley Basin
B ✤	= Chevron Resources Co.	Panna Maria
C ⁜	= Power Resources	Highland
D ⁜	= Uranium Resources	Rosita
E ⁜	= Freeport Uranium	Donaldsville & Uncle Sam
F ⁜	= IMC [1]	New Wales & Plant City
G ✾	= Allied Chemical Corp.	Metropolis
H ✾	= Sequoyah Fuels Corp.	Gore
I ➡	= Department of Energy	Paducah
J ➡	= Department of Energy	Portsmouth

[1] IMC = International Minerals and Chemical Corporation

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ARGENTINA

Argentina has two nuclear power plants in commercial operation and a third under construction. Atucha 1, a 335-MWe heavy water reactor supplied by Kraftwerk Union, was shut down for repairs for 17 months until January 1990. It was shut down again in July to resume removal of fragments from the vessel. The average capacity factor for Atucha 1 in 1990 was 53 percent. Embalse, a 600-MWe CANDU (heavy water) reactor, is currently operating, but also has suffered operational problems. The average capacity factor for Embalse was 78 percent in 1990. The third unit, Atucha 2, a 692-MWe pressurized heavy water reactor is about 68-percent complete (**Figure 33**). Design changes and financing problems have pushed back Atucha 2's completion date to 1994. The future of this third nuclear plant now appears to be more secure: Argentina has reached an agreement with Germany to receive matching-fund loans to secure the US$1.4 billion required for Atucha 2's completion.

Argentina's President, Carlos Menem, continues to support the government's commitment to nuclear fuel cycle self-sufficiency. The government plans to use nuclear power to partially alleviate the severe electricity shortages the country has experienced in the last few years. But, in order to finance new reactors and develop a successful nuclear power program, Argentina must resolve its national debt repayment problems.

In a significant breakthrough, Argentina and Brazil announced the joint negotiation of a full-scope safeguards agreement with the International Atomic Energy Agency that would result in outside inspection of all their nuclear material. The blueprint for the proposed IAEA safeguards accord is the 1967 Treaty of Tlateloco, which established Latin America as a nuclear-weapons-free zone. Argentina has signed, but not ratified, the Tlateloco Treaty, and without ratification, the country does not have to implement the terms of the treaty. No date has yet been set

Figure 33 — Atucha 2, a 692-MWe pressurized water reactor, under construction.
(Photo courtesy of Siemens AG.)

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for an IAEA accord, due to the reservations of both Argentina and Brazil about some of the Tlateloco clauses. The two countries have also agreed to open all of their nuclear facilities to inspection by each other, neither country has signed the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).

Fuel Cycle Facilities

Although Argentina has several fuel cycle projects under construction, all were characterized by delays and problems in 1990.

- Budget cutbacks caused delays in the expansion of the Pilcaniyeu gaseous diffusion enrichment plant from 40,000 SWU per year to 100,000 SWU per year. As a result, Argentina may be forced to renegotiate supply contracts.
- Argentina's economic problems have repeatedly delayed the completion and startup of a 250 tons-per-year heavy water plant at Arroyito. The original manager of the project, Sulzer Bros. of Switzerland, was replaced in April 1990.
- Economic problems have also delayed construction of a zircalloy fuel fabrication plant, and completion of the pilot reprocessing plant at Ezeiza with a capacity of five tons of heavy metal per year.

Since 1985, most of the fuel used in the country's two operating domestic reactors has been supplied by Argentine uranium mines. Argentina has been operating two mines domestically: San Rafael and La Estela. The country has over 30 million pounds equivalent U_3O_8 in reasonably assured uranium reserves. Concentrates are converted to uranium dioxide at a plant near Cordoba, which has a two-line capacity of 300 tons per year. Conversion to UF_6 and enrichment to 0.85 w/o U^{235} occurs at the Pilcaniyeu facility.

Argentina intends to be the leader in nuclear power development in Latin America and other developing nations. It is developing reactor designs for domestic and export use. In late October 1990, Argentina and Turkey agreed to form a joint architectural/engineering firm to develop Argentina's modular 25-MWe Carem 15 light water reactor. In 1989, Argentina signed an agreement with Brazil on cooperation for long-term fast breeder reactor development. The Soviet Union also has signed an agreement with Argentina to share breeder reactor technology, with all technology transfers covered by IAEA safeguards.

Table 39
NUCLEAR POWER UNITS IN ARGENTINA

Units In Operation

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD[1]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh net)
Atucha 1	CNEA[2]	335	PHWR	1974	53	1,553
Embalse	CNEA	600	HWR	1984	78	4,093
TOTAL		935		*(1990 Average:* 69)		5,646

Units Under Construction

Unit	Lead Utility or Fuel Buyer	Capacity (MWe net)	Type	COD	Percent Complete[3]	
Atucha 2	CNEA	692	PHWR	1994	68	—

[1] COD = Commercial Operation Date (actual or expected)
[2] CNEA = Comision Nacional de Energia Atomica
[3] Source: *Nuclear News*

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BRAZIL

Brazil's only operating reactor, Angra 1, a 626-MWe pressurized water reactor (PWR), was restarted in January 1990, after its second refueling outage begun October 1, 1989. Angra 1 was scheduled to restart in December, but members of Brazil's Green Party obtained a court order preventing the restart. However, the court order was overturned as the result of a favorable review from a recent International Atomic Energy Agency Operational Safety Review Team (OSART), and the reactor was permitted to resume operation.

Figure 34 — Angra 2, a 1245-MWe PWR, under construction. (*Photo courtesy of Siemens AG.*)

Angra 2 and 3, both 1245-MWe PWRs, are under construction and scheduled for completion in the 1990s (**Table 40**). Angra 2 is 64 percent complete (**Figure 34**) and Angra 3, about 39 percent complete; but due to budgetary problems the completion of Angra 3 is uncertain. In the past decade, slow growth in electricity demand, excessive foreign debt, and hyperinflation have slowed progress of Brazil's nuclear power program.

Although Brazil's President, Fernando Collor, supports nuclear power, the country's severe economic crisis will continue to hold back the development of its nuclear industry in the near term. When President Collor was inaugurated in March 1990, inflation was greater than 1,200 percent per year. In a move to regain control of the economy, Collor imposed a radical reform package that included:

- Freezing all financial assets worth US$1,200 or more, for 18 months.
- Abolishing two dozen government agencies and laying off over 100,000 government employees.
- Announcing plans to privatize most state-owned industries.
- Adopting an aggressive plan to protect the Amazon Rain Forest.

While successful implementation of these radical reforms may be difficult, the proposed reform in the electrical industry was desperately needed and should succeed. The government's plans for the industry include raising rates more than 30 percent: with monthly inflation reduced to single digits, utilities would have a realistic chance of recovering costs. Improving their financial situation could increase investor confidence and encourage international investors to resume lending money to be used to complete several power projects. Encouragement of private enterprise to enter the electrical industry is the most important aspect of the government's plan for the industry; the government hopes the private sector will contribute up to one-third of the country's forecast additional power needs by the year 2000.

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In another important development during 1990, Brazil and Argentina announced that they will jointly negotiate a full-scope safeguards agreement with the IAEA to place all their nuclear material under outside inspection. The proposed IAEA safeguards accord will be based on the 1967 Treaty of Tlateloco. The two nations have also agreed to open all of their nuclear facilities to inspection by each other. Like Argentina, Brazil has not signed the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).

Fuel Cycle Facilities

Brazil's military has had a tremendous influence in the country's nuclear program. But in 1990, President Collor moved aggressively to end the military aims of the program, and devote the country's resources to peaceful power development. Brazil has a small enrichment facility at Rezende that is currently shut down. The country has another small gas ultracentrifuge enrichment plant at Ipero. Its current output is less than 1,000 SWU per year, but the military has proposed to increase its capacity to 100,000 SWU per year. Political and economic considerations will limit this proposal, but the plant could be expanded during the 1990s. The IAEA safeguards negotiations will have a major impact on the plant's future.

At present, the Pocos de Caldas mine is the only active mine site with its own mill. The Pocos de Caldas mine produced approximately 100 thousand pounds equivalent U_3O_8 in 1990. Brazil's state-owned uranium production and processing company, Uranio do Brasil, announced that it will begin to shift its production from the high-cost and nearly depleted deposits at Poco de Caldas, to lower-cost reserves at Lagoa Real. Production at Lagoa Real is scheduled to begin by 1993.

Table 40
NUCLEAR POWER UNITS IN BRAZIL

Unit	Lead Utility or Fuel Buyer	Capacity (MWe Net)	Type	COD[1]	Percent Complete[2]	1990 Capacity Factor (percent)	Total 1990 Electricity Generation (GWh net)
Angra 1	Furnas[3]	626	PWR	1984	100	35	1,942
Angra 2	Furnas	1,245	PWR	1997	64	—	—
Angra 3	Furnas	1,245	PWR	2001	39	—	—

[1] COD = Commercial Operation Date (actual or expected)
[2] Source: *Nuclear News*
[3] Furnas Centrais Electricas SA

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NUEXCO MARKET VALUES:
DEFINITIONS, DERIVATIONS, AND COMMENTS

DEFINITIONS

- The **Exchange Value** is NUEXCO's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.

- The **UF_6 Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.

- The **Loan Rate** is NUEXCO's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.

- The **Conversion Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.

- The **SWU Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of enrichment services could be concluded as of the date indicated.

- The **Transaction Value** is a weighted-average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
  - Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
  - At least ten transactions;
  - Transactions involving a sum total of at least 2 million pounds equivalent U_3O_8.

DERIVATIONS AND COMMENTS

- All **Market Values** are expressed in terms of US$.

- All **Market Values** are based on:
  - Data from recently completed transactions.
  - Data from pending transactions.
  - Firm bids to buy or borrow, and firm offers to sell or lend.
  - Prices purchasers or rates borrowers have expressed a willingness to pay, but for which NUEXCO is not aware of firm bids to buy or borrow and prices sellers or rates lenders have expressed a willingness to accept, but for which NUEXCO is not aware of firm offers to sell or lend.

- Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these **Market Values**.

- In the determination of prices, NUEXCO does not consider charges for transportation other than that customarily provided by suppliers.

- The prices of services or materials delivered under long-term contracts with primary suppliers are not considered in the determination of the listed values.

- For the **SWU Value**, NUEXCO converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight percent U^{235} and a product assay of 3.0 weight-percent U^{235}, assuming feed costs corresponding to the NUEXCO **Exchange Value** and **Conversion Value** determined as of the same date.

- In calculating the **Transaction Value**, NUEXCO does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future **Exchange Values** or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it can not currently be determined.

- The sample time for the **Transaction Value** is extended as necessary to satisfy the minima for the number of transactions and quantity of material. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

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